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The Ohio Naturalist and Journal of Science

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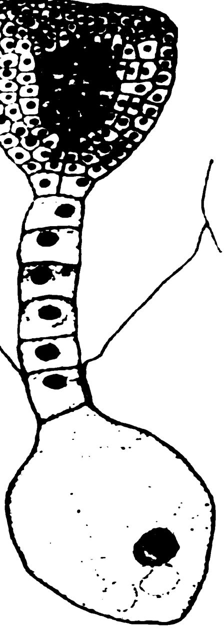

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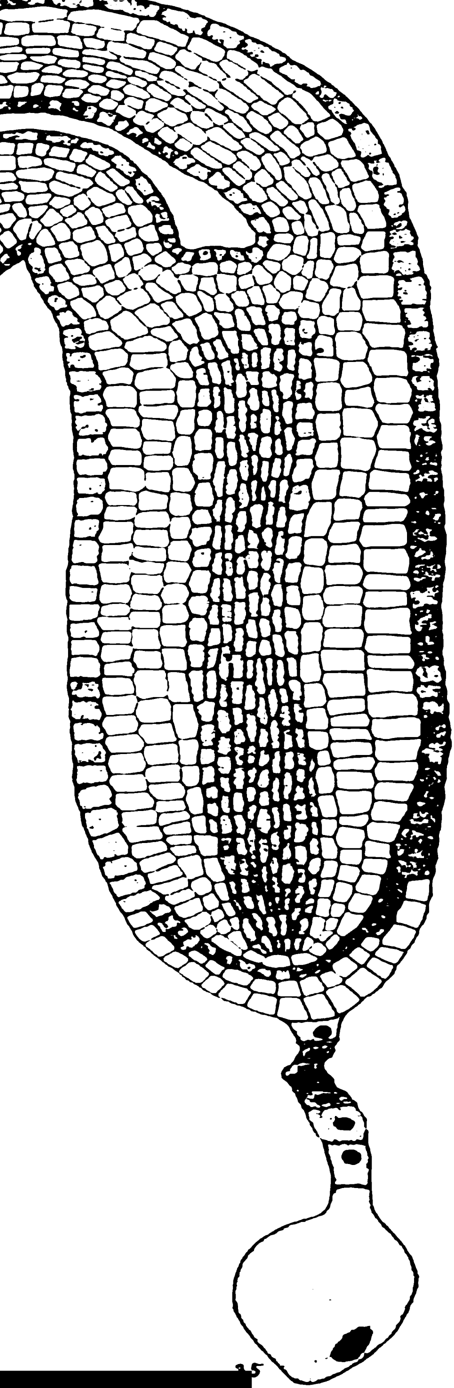

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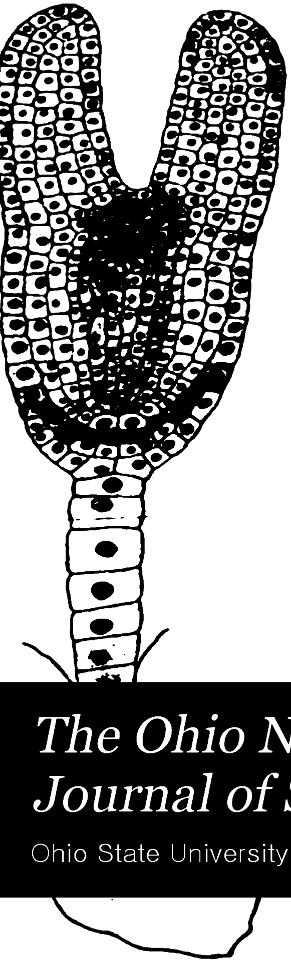

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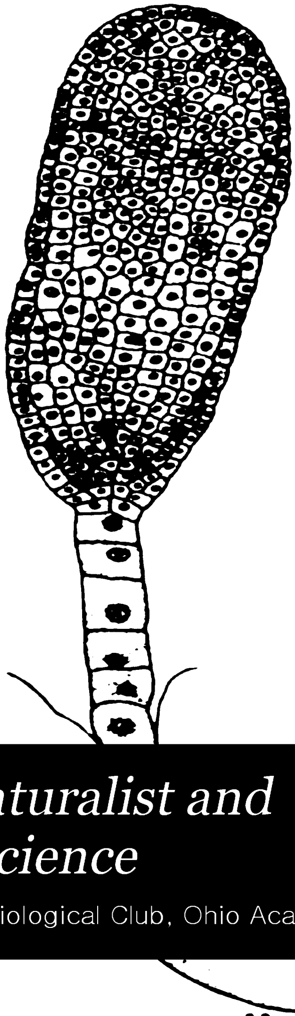

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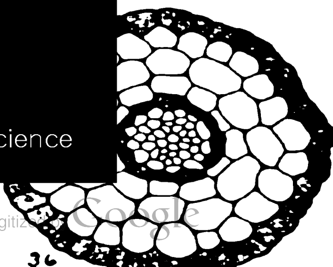

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W. G. FARLOW

The Ohio Naturalist

Official Organ of THE BIOLOGICAL CLUB OF THE OHIO STATE UNIVERSITY,
and of THE OHIO STATE ACADEMY OF SCIENCE.

Volumes VII, VIII and IX, 1906–1909.

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The Ohio Naturalist,

PUBLISHED BY

The Biological Club of the Ohio State University.

Volume VII. NOVEMBER, 1906. No. 1.

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THE EMBRYOLOGY OF THE SHEPHERD'S PURSE.*

(A Posthumous Paper.)

MABEL SCHAFFNER.

The embryo of the shepherd's purse (*Bursa bursa-pastoris* (L.) Britt.) has had an important place as a representative dicotyl in most botanical textbooks. The original investigations of Hanstein (1) and Famintzin (2) were superior and epoch-making for their day, yet many points were left obscure and some of these are still unsettled, as a reference to the various botanical textbooks will show. Considerable variation has been reported as to the succession of the cell divisions and other minor details. The best recent account is by Coulter and Chamberlain (4, 5), and what is given below is practically a confirmation of their report with a few differences in details.

The embryology of Alyssum as given by Miss Riddle (3) shows several interesting deviations from the Bursa type and makes it clear that generalizations can not be made without full knowledge even in the case of closely related plants.

It was my intention to make a complete study of the embryo of Bursa and to prepare a series of drawings on the same scale of magnification in order that not only the succession of cell divisions and the development of the several embryonic tissues would be apparent but also the actual increase in size of the embryo as a whole and of the cells at various stages of development.

The ordinary methods of killing and imbedding were employed and the serial sections, cut 10–12 mic. thick, were stained on the slide. Delafield's haematoxylin makes a very satisfactory stain if properly employed.

---

*Contributions from the Botanical Laboratory of the Ohio State University, XXV.

The egg apparatus of Bursa is well organized and after fertilization the oospore elongates considerably and divides by a transverse wall into two cells of unequal size (Figs. 1–5). The basal cell does not divide again but begins to enlarge rapidly, finally developing into a large vesicular cell which is closely surrounded by the upper part of the wall of the ovule and continues in an active condition until the seed ripens. The upper cell divides by a transverse wall giving rise to a proembryo of three cells, the terminal cell, an intermediate cell, and the basal vesicular cell (Fig. 6). The next division is again transverse and probably takes place in the intermediate cell (Fig. 7). After a filament of four cells is produced, the apical or terminal embryo cell divides by a longitudinal wall, giving rise to the typical five-celled embryo (Fig. 8). The following division occurs in the suspensor cell next to the vesicular cell, resulting in a six-celled embryo with five tiers (Figs. 9–11). Often the cell below the two terminal embryo cells stains dark like them while the three suspensor cells take a much lighter stain (Figs. 10,11). This would indicate that this cell is the second cell of the embryo proper and that it does not contribute to the further development of the filamentous suspensor until its division at a much later stage. This point was, however, not determined. The two terminal cells now divide by longitudinal walls at right angles to the previous division giving rise to the terminal quadrants while further transverse divisions occur in the suspensor (Figs. 12–15).

At the time when the terminal quadrants divide by transverse walls to form the octants, the suspensor usually consists of the vesicular cell and six intermediate cells (Figs. 16–20) and this is frequently the extent of this organ though more commonly there are seven or eight intermediate suspensor cells developed. The cotyledonary and hypocotyledonary rgeions of the embryo are definitely separated by the divisions which give rise to the octants. The octants soon cut off dermatogen cells by periclinal walls thus producing a nearly spherical body of sixteen cells (Figs. 17, 18). The periclinal divisions which give rise to the dermatogen appear first in the terminal octants (Fig. 17). At this stage the proembryo consists typically of twenty-two or twenty-three cells. While the dermatogen cells are continuing their divisions by anticlinal walls the eight inner cells divide by longitudinal walls and the cell between the suspensor proper and the terminal sphere divides by a transverse wall into the basal embryo cell and a very flat disk-like suspensor cell which takes no part in the development of the embryonic tissues (Fig. 19).

The primary dermatogen begins its further development in the outer quadrants of cells and as would be expected the division in these cells is more active during the further growth of the embryo than in the lower quadrant. Frequently the formation of anticlinal walls in the dermatogen is delayed until after the division of the upper suspensor cell (Fig. 20).

The entire embryo is, therefore, developed from the two cells at the outer tip of the proembryo, the terminal cell, as will appear later, giving rise to the cotyledons, stem tip and hypocotyl while the basal cell after cutting off one suspensor cell gives rise to the calyptrogen, root tip, and calyptra.

The further development of the embryonic sphere is by the division of the lower tier of inner cells by transverse walls. There are then three tiers of cells in the sphere besides the dermatogen (Figs. 24–28). These divisions were established by the presence of spindles in the lower tier as in Fig. 24. Frequently also the outer tier of cells takes a much deeper stain than the other two tiers as is shown in Fig. 28. When these divisions begin the basal embryo cell divides by a transverse wall, the resulting cells being the incepts of the growing point of the root tip and the calyptrogen (Figs. 24–26). The upper cell, usually lenticular in shape, divides first forming a plate of four cells by the development of longitudinal walls (Fig. 28). These four cells remain dormant for some time but continue division before the embryo reaches maturity.

The two lower tiers in the embryonic sphere now begin to differentiate into a central plerome and the surrounding periblem and at the same time the lowest cell of the embryo proper or the incipient calyptrogen cell divides by longitudinal walls into four cells followed by transverse or periclinal walls which differentiate the primary layers of the calyptra and calyptrogen (Figs. 29–32). This periclinal division extends out into the dermatogen cells derived from the primary octant as will appear from an inspection of Figs. 29, 30 and 32. The calyptrogen thus is developed from cells derived from both he terminal and basal embryo cell. As stated before the embryo proper is developed entirely from two original tiers of cells each developing octants, but the terminal cell divides first by longitudinal walls and its development is far advanced before the basal cell begins its division which is always transverse in Bursa although longitudinal in Alyssum.

The cotyledons and plumule have their origin from the outer cells of the original octant while the hypocotyl is developed from the basal octants. The nearly spherical embryo begins to take on a flattened appearance at the outer end (Fig. 28) and later, by the appearance of two large protuberances, the incipient cotyledons, it is heart-shaped in properly cut longitudinal sections. The embryo remains straight until by rapid elongation the cotyledons are forced around by the curved wall of the ovule (Figs. 34, 35). When the embryo is approaching maturity the cells of the hypocotyledonary region and root tip undergo rapid division so that the entire length of the cavity of the ovule is filled and the suspensor cells are crushed (Figs. 35, 37). But the vesicular cell retains its active appearance to the end.

The plerome consists of a bundle of small elongated cells surrounded by a sheath of larger cells and the periblem consists of two layers with an inner limiting layer. The sheath of the plerome and the inner layer of the periblem have a common origin as will appear from an inspection of Figs. 36 and 38. The nature of these two layers was not determined. In the mature embryo the cotyledons are well developed but it is difficult to obtain central sections because of the curving and folding. Usually when one has a central section of the radicle the sections of the cotyledons will be more or less tangential.

ADDENDUM.

The foregoing paper was left in an incomplete condition at the time of my wife's untimely death. It was her desire to work out the embryogeny of Bursa step by step as a preliminary to other embrylological studies which she had begun. However, the work was so nearly complete that it was thought advisable to publish it as it was left although a few spindle stages are lacking for a complete series. Just before her last sickness she had prepared material collected at various times of the day and night in the hope of being able to fill out the missing stages.

The series of figures, all drawn on the same scale, represent to the eye the actual increase of the embryo in size at each stage of development and will be of considerable use to students for reference.

To be cut off in the midst of work and plans for the future was her sad lot, and, without referring to my personal loss, it is with a sorrowful heart that I contemplate her passing away so long before her bright hopes and ambitions were realized.

JOHN H. SCHAFFNER.

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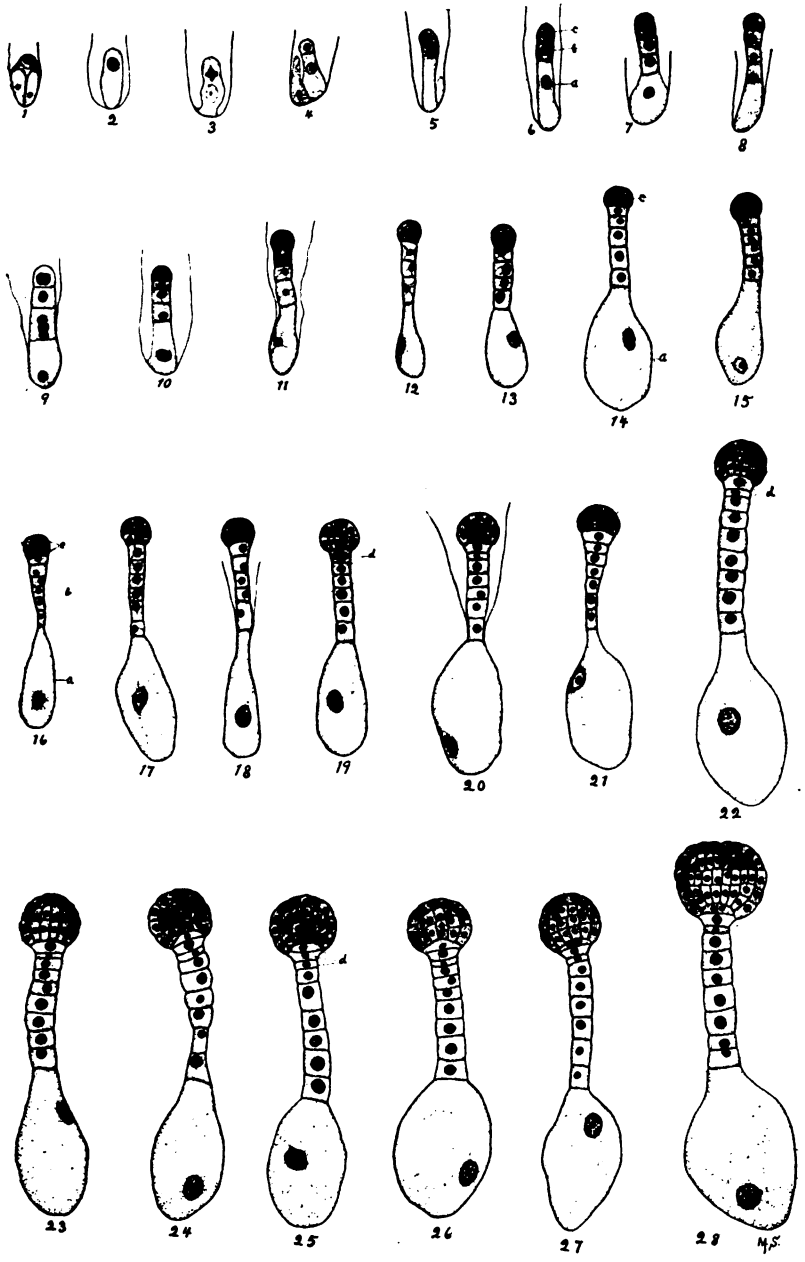
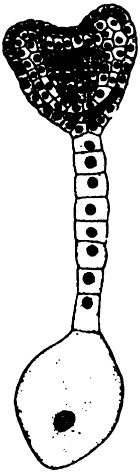
OHIO NATURALIST. *Plate I.*



MABEL SCHAFFNER on "Shepherd's Purse."

OHIO NATURALIST. *Plate II.*



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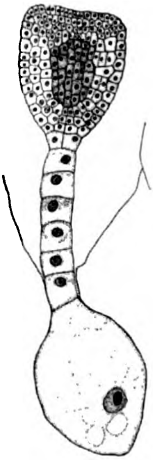

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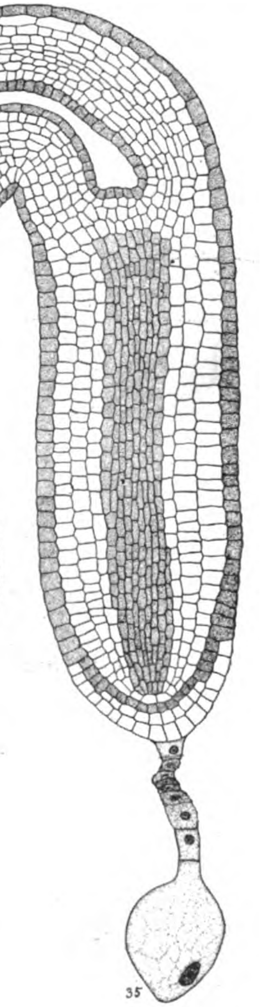

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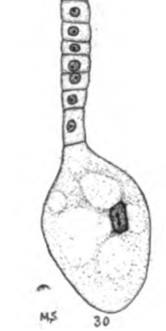

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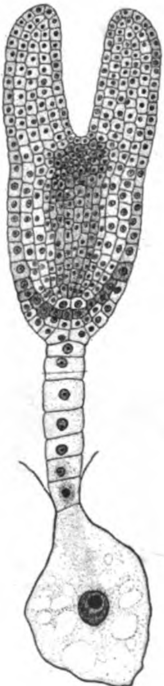

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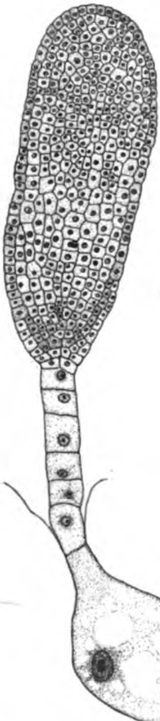

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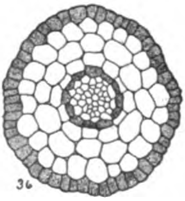

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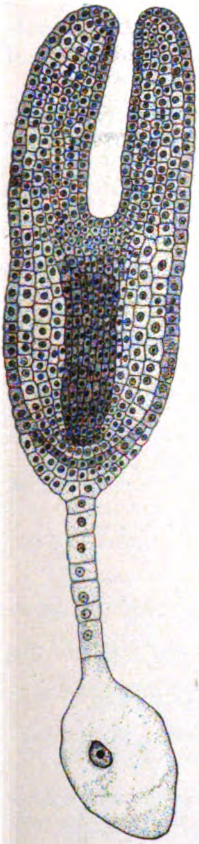
Mabel Schaffner on "Shepherd's Purse."

OHIO NATURALIST. *Plate III.*



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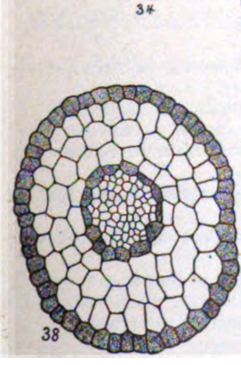

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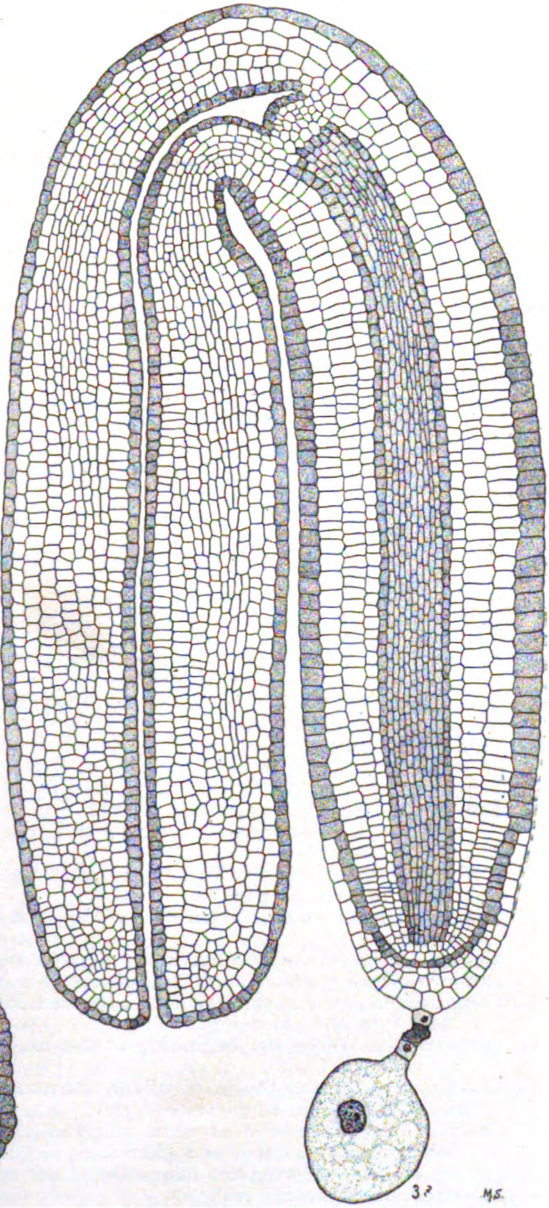

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MABEL SCHAFFNER on "Shepherd's Purse."

EXPLANATION OF PLATES I, II, AND III.

The drawings are all on the same scale and were reduced to $\frac{1}{5}$ of their original size. A combination of Zeiss 18 compensating ocular and Zeiss 8.0 mm. Apochromat objective was employed with a magnification on the table of about 900.

1. Egg apparatus with oosphere.
2. Elongated oospore.
3. Oospore dividing.
4. Two-celled embryo and synergid.
5. Two-celled embryo.
6. Three-celled embryo.
7. Four-celled embryo.
8. Five-celled embryo.
9. Incipient six-celled embryo.
10. Six-celled embryo.
11. Older six-celled embryo with the upper two tiers of cells stained much darker than the rest.
12. Eight-celled embryo; the tip in the quadrant stage.
13. Nine-celled embryo with four-celled tip.
14. Ten-celled embryo with four-celled tip.
15. Eleven-celled embryo with four-celled tip.
16. Fifteen-celled embryo with octants at the tip and seven suspensor cells.
17. Same stage as the preceding, the octants cutting off the primary dermatogen.
18. Twenty-two-celled embryo with primary dermatogen complete, the normal embryo at this stage has twenty-three cells.
19. Embryo with the cell adjoining the embryonic sphere undergoing transverse division.
20. Typical twenty-four-celled embryo.
21. Embryo with longitudinal division beginning in the lower tier of the inner octants.
22. Typical embryo with ten-celled suspensor.
23. Somewhat later stage showing rapid multiplication of the upper dermatogen cells.
24. Embryo showing division of the basal embryo cell and origin of the third tier in the embryonic sphere.
25. Typical embryo at time when the lower two embryo cells are ready for further development.
26. Same stage as the preceding but somewhat one-sided in development and with a different number of cells in the suspensor.
27. Embryo showing first division of the root tip cell.
28. Embryo showing the outer tier of cells from which the cotyledons and plumule are derived with a much darker stain than the rest of the tissues.
29. Embryo showing origin of cotyledons, stem tip, hypocotyl, root tip, calyptrogen and calyptra.
30. Somewhat older embryo than the preceding showing further development.
31. Median section of embryo cut in same plane as the cotyledons.
32. Embryo showing cells of stem tip and second division of calyptrogen.
33. Longitudinal section through one cotyledon of embryo somewhat older than the preceding.
34. Embryo just before the beginning of the final rapid elongation of the radicle.
35. Embryo showing the condition of the tissues at the stage when the cotyledons begin to curve.
36. Cross section of embryo at same stage as the preceding showing dermatogen, periblem and plerome.
37. Mature embryo showing the character of the embryonic tissues.
38. Cross section of mature embryo.

SOME GUATEMALAN ORTHOPTERA, WITH DESCRIPTIONS OF FIVE NEW SPECIES.

LAWRENCE BRUNER.

The twenty-eight species of Orthoptera reported in this paper were collected during the winter of 1905 by James S. Hine, of Columbus, O., who referred them to the writer for determination. Although the collection is but a small one it is very interesting since it contains specimens of at least four species which appear to be new to science and others that materially extend the range of known forms. One of the new species, *Cornops scudderi*, adds a South American genus hitherto not reported for North America.

Family BLATTIDAE.

1. **Pseudophyllodromia venosa** Sauss. This insect is represented by a single specimen taken at Mazatenago, February 3.
2. **Blabera trapezoidea** Burm. A single male of this large cockroach was collected at Santa Lucia February 1.

Family MANTIDAE.

3. **Stagmomantis dimidiata** Burm. The species is represented by a fine male which was captured March 5, at Puerto Barrios. A female nymph that was taken at San Jose on February 5 is also referred here.

Family GRYLLIDAE.

4. **Oecanthus nigricornis** Walk.(?) The collection contains two males of a tree-cricket which were taken on February 7, at Amatitlan. One of these has the greater portion of the antennae pale testaceous instead of black, as described by Walker. Both, however, lack the black lines or dots on the two basal antennal joints, thereby agreeing with the insect that Henri de Saussure takes to be Walker's *nigricornis*, but perhaps erroneously, as the types of Walker's insect came from Illinois.
5. **Oecanthus varicornis** Walk.(?) A single female with the two basal antennal joints unifasiate with black, but otherwise agreeing very closely with the preceding, is referred here. It was taken at the same time and place with them.
6. **Paroecanthus aztecus** Sauss. The single specimen, a female, of this species comes from Gualan where it was captured on March 3.

Family LOCUSTIDAE.

7. **Hormilia tolteca** Sauss. Three specimens, two males and a female, are at hand from Mazatenango. They were collected February 3.
8. **Orophus conspersus** Brunn. A single female of this species was taken at Mazatenango on February 8.
9. **Orophus tessellatus** Sauss. A single female taken February 2, is labelled as coming from Santa Lucia.
10. **Eriolus consobrinus** Sauss. et Pict. On February 1, a female of this species was taken at Santa Lucia.
11. **Thysdrus infirmus** Sauss. et Pict. The collection contains a pair of this delicate species. They come from Mazatenango, and were captured February 3.
12. **Idiarthron atrispinum** Stal. The insect before me is a little large as compared with the measurements given in Brunner's monograph, of the Pseudophyllidae, but it agrees in other respects with Stal's *Meroncidius atrispinosus*. It comes from Santa Lucia, where it was taken February 1.

Family Acridiidae.

13. **Paratetix mexicanus** Sauss. The collection contains a single male specimen of this species. It was taken on March 8, at Puerto Barrios.

14. **Tettigidea chichimeca** Sauss. A single female specimen represents the present species so far as the collection now before me is concerned. It also comes from Puerto Barrios, where it was taken on the same date as the last.

15. **Amblytropidia costaricensis** Bruner. The only representative of this rather common genus in tropical America is a single specimen of *A. costaricensis*. It was taken February 7, at Amatitlan.

16. **Orphula guatemalae** n. sp. Most nearly related to *O. azteca* Saussure, but differing from it in its smaller size and slenderer form. It differs also in the female by having a more uniform color—the tegmina maculations are fewer and smaller, and the basal joints of the antennae are less depressed. The hind femora of both sexes are also shorter and more graceful. The valves of the ovipositor are shorter and slenderer than in *azteca* or *meridionalis*. In its general color the present species varies from pale testaceo-ferruginous to dark brown in the female, while the males have the dorsum of occiput, pronotum and tegmina testaceous or green. In the male the sides of the head, pronotum, pleura and costal and discal field of tegmina are unspotted brown; the lateral pronotal carinae are edged below with dark piceous in both sexes. Abdomen venter and face pale testaceous, the legs a little darker and somewhat infuscated at the knees. Sides of basal abdominal segments of male more or less piceous.

Length of body, ♂, 15.5 mm., ♀, 22.5 mm.; of pronotum, ♂, 3 mm., ♀, 4 mm.; of tegmina, ♂, 13,25 mm., ♀, 17 mm.; of hind femora, ♂, 9.5 mm., ♀, 12.25 mm.

Habitat. The types,male and female, come from Santa Lucia where they were collected February 1. The collection also contains an additional female from the same locality and a pair from Mazatenango, February 3.

The following table will show the realtionship of the species:

Synoptic Table of the Species of Orphula.

A1. Fastigium of the vertex with its antero-lateral egdes decidedly rounded. Basal joints of antennae greatly depressed. Lateral carinae of the pronotum only gently divergent on the hind lobe. PAGANA Stal.

A2. Fastigium of the vertex with its anteor-lateral edges nearly ly straight. Basal joints of the antennae only gently depressed. Lateral carinae of the pronotum strongly divergent on the hind lobe.

  b^1. Lateral carinae of the anterior lobe of the pronotum parallel (Costa Rica) MERIDIONALIS Bruner

  b^2. Lateral crainae of the anterior lobe of the pronotum plainly divergent.

    c^1. Larger and more robust (Mexico southerly) AZTECA Sauss

    c^2. Smaller and rather slender (Guatemala) GUATEMALAE n. sp.

17. **Orphulella arctata** Walk.(?) There are four specimens, 1 female and 3 males, of a locust that are doubtfully referred to Walker's *arctata*. They come from San Jose, where they were taken on February 5.

18. **Orphulella meridionalis** Bruner. One male and one female, Puerto Barrios, March 3.

19. **Orphulella walkeri** n. sp. Below medium in size, rather slender, the antennae of male graceful and decidedly longer than the head and pronotum combined. Color variable, ranging from testaceous to green varied with brown and black.

Eyes prominent, considerably (♂) or a trifle (♀) longer than the cheeks below them; fastigium of the vertex with the sides parallel two-thirds its length, acuminate even in the female and unusually deeply sulcate, lateral foveolae well defined, elongate triangular; frontal costa prominent above the ocellus where they are coarsely and paucily punctate; face rather oblique; antennae long and slender. Pronotum slightly expanding posteriorly, the two lobes about equal in length, the lateral carina in advance of the last transverse sulcus straight and very gently diverging anteriorly. Tegmina in the female provided with two rows of cells, of moderate width and gently surpassing the apices of the hind formora in both sexes, in the female rather sparsely and evenly maculate with fuscous, in the male unspotted but with the dorsal field pale testaceous, the hind femora without markings or bands save for the knees which are infuscated apically. Wings infuscated or cloudy.

Length of body, ♂ 13.5 mm., ♀ 19 mm.; of antennae, ♂ 6.5 mm., ♀ 6 mm.; of pronotum, ♂ 2.5 mm., ♀ 3.95 mm.; of tegmina, ♂ 11.5 mm., ♀ 14.3 mm.; of hind femora, ♂ 9.25 mm., ♀ 10.55 mm.

Habitat. The types, ♂ and ♀, were collected February 22, at Los Amates, while an additional male was taken at Puerto Barrios, on March 3.

If we should attempt to run this insect out by the synoptic table as given by the author in the "Biologia Centrali Americana, Orthopt. II, pp. 74-78," it would fall into the section A^2 under b^2 along with *prominula* and *robusta*, but the table would have to be modified as follows:

b^2. Lateral carinae of the pronotum not arcuate, either straight throughout or parallel on the anterior lobe and more or less divergent on the posterior one.
  c^1. Antennae of the male more than ordinarily heavy; the insects rather robust.
    d^1. Lateral carinae of the pronotum gently and evenly divergent posteriorly. Eyes prominent, elongate. Face strongly oblique. PROMINULA Bruner.
    d^2. Lateral carinae of the pronotum divergent on the posterior lobe only. Eyes less prominent, subglobular. Face only moderately oblique. ROBUSTA Bruner.
  c^2. Antennae of the male filiform, slender. The insect rather graceful. WALKERI n. sp.

This might be one of Walker's species of *Stenobothrus* which he described in the Catalogue of the Dermaptera Saltatoria in the British Museum. It is almost impossible, however, to determine his species from the meager descriptions given.

20. **Heliastus guatemalae** Sauss. Several specimens, males and females, are in the collection. They come from Amatitlan, February 3, and Jan Jose, February 5. They do not differ very greatly in general color and form from *H. sumichrasti* Sauss., but the disk of the wings of guatemalae is yellow instead of red.

21. **Arnilia minor** n. sp. Very similar in form to *Arnilia chlorizans* Walker, but differing from it in the much smaller size and in the entire absence of the pale band along the sides of the head, pronotum and pleura. The last ventral segment of the male abdomen is also quite different.

Fastigium of the vertex elongate, triangular, with a moderately broad but shallow median longitudinal sulcus, the apex slightly acuminate; frontal costa rather deeply sulcate, widened above the antennae, nearly equal below, the face unicolorous, impunctate, strongly oblique; antennae only a trifle longer than the head and pronotum taken together; eyes moderately prominent, a little less divergent than in the males of *A. chlorizans*, about twice the length of that portion of the cheeks below them. Pronotum subcylindrical, rather closely and finely punctate, much more closely so in front and on the hind lobe, the latter with a prominent median carina and short shoulders, about four-fifths as long as on the anterior lobes. Tegmina narrow, extending one-fifth of their length beyond the apex of the abdomen. Hind femora slender, smooth, as long as the abdomen. The latter graceful, tapering, the last ventral segment short and provided with a lateral blunt tooth at each side, the center prolonged into a short boot-like projection in which the toe is directed to the rear. Hind tibiae slender, the lateral carinae poorly developed as compared with some of the other species of the genus. Prosternal spine slender, straight, the apex evenly rounded.

General color pale grass-green above, yellowish white below. Wings caerulean, the dorsum of the abdomen leaden gray. Antennae ferriginous, clypeus, labrum, tip of last ventral segment and hind tarsi pink.

Length of body, 22 mm., of antennae, 7 mm., of pronotum, 3.65 mm., of tegmina, 20 mm., of hind femora, 11.5 mm.

Habitat. A single male from San Jose, February 5.

This genus appears to be represented by quite a number of species—a dozen or more—when we consider the two Americas. They fall into two well defined sections or possibly into distinct genera.

22. **Arnilia** sp. The collection also contains a single female specimen of what appears to be a second species of *Arnilia*; but, since there are at least a half-dozen distinct species of similar size at hand as I write, it is difficult to definitely place it with certainty. The characters, so far as observed, are more pronounced in the males, and until I have had an opprotunity to critically study the dozen or more species of the genus of which I have specimens no attempt will be made to determine the individual just referred to. It was taken February 6, at Amatitlan.

23. **Inusia obscura** (Thumb.) (?) Two pairs of a slender locust taken at Los Amates, February 25–27, are referred with some doubt to Thunberg's *Acridium obscurum*. Whether they are that insect or not, they belong to Giglio-Tos' genus *Inusia* which contains two or three representatives in tropical America.

24. **Cornops scudderi** n. sp. A moderately robust, medium sized, grass-green and testaceous insect with a broad piceous band on each side which extends from the back edge of the eyes along the upper half of the pronotum and pleura and is bordered below by one of greenish yellow. The costal margin and disc of the tegmina are dark brown or fuscous.

Head somewhat wider than the front edge of the pronotum; the eyes a little prominent and strongly divergent, a trifle longer than that portion of the cheeks below them; vertex nearly as broad as the frontal costa between the antennae, rather deeply sulcate to the tip of the fastigium, the latter a little wider than long, somewhat depressed and blunt in front; frontal costa prominent, a little widest above the ocellus, gently sulcate, coarsely but shallowly punctate, as is in fact the whole face, the punctures brown; occiput rather long, the eyes distant from the front edge of the pronotum; antennae filiform, nearly as long as the hind femora, the basal joint robust and green, the balance brown. Pronotum subcylindrical, the surface coarsely punctate, on the anterior lobe distantly, on the hind lobe rather closely; front margin rather broadly rounded, hind margin widely obtuse angulate, anterior half of lower edges obliquely truncate; transverse impressed lines continuous, profound, the hind lobe much shorter than the anterior one, the median carina distinct throughout but most apparent on hind lobe. Tegmina of medium width, extending a little beyond the apex of hind femora, their tpis rounded, with the upper portion a little truncate. Hind femora robust extending one-fourth their length beyond the tip of abdomen; hind tibiae seven-spined on the outside. Abdomen tapering, the last ventral segment short, upturned and contracted to a narrow prow-shaped projection; the supra-anal plate broader than long, the sides of basal two-thirds broadly rounded and strongly convergent, the apical third with straight sides and evenly rounded apex, middle of basal portion provided with two parallel lines and the sides with two dots of black; cerci of the usual form for this group.

Length of body, 18 mm., of pronotum, 3.8 mm., of tegmina, 16 mm., of hind femora, 11 mm., of antennae, 10 mm.

Habitat. The single male type was taken March 11, at Puerto Barrios.

25. **Vilerna aeneo-oculata** DeG.(?) Two males and two females of this genus are at hand from Mazatenango. They were taken March 3.

Saussure described an insect under the name of *Xipicera pygmaea* (Revue et Magasin de Zoologie, Mars 1861, p. 131.) and gave as its habitat simply "Mexico." A specimen bearing Saussure's label is before me as I write. It is a *Vilerna* and undoubtedly distinct from *aeneo-oculata*. The four Guatemalan specimens in the present collection are distinct from Saussure's and are fererd with some doubt to DeGeer's species from South America.

26. **Schistocerca pyramidata** Scudd.(?) There are specimens of a large *Schistocerca* in the collection from Los Amatas, which are placed here with some doubt. They were collected February 20. These insects vary from pale rufo-testaceous with scarcely any tarce of maculation to dark gray-brown and strongly maculate on the tegmina—nearly or quite as plainly as *S. vaga* Scudd.

27. **Aidemona azteca** Sauss. There are four specimens of this very common and widely dispersed locust in the collection. They were taken at Mazatenango on the 3rd of February.

28. **Osmilia tolteca** Sauss. Every locality in southern Mexico and southward to Costa Rica, contains plenty of specimens of this locust. It is represented by about a score of individuals from all the localities where Orthoptera were taken by Prof. Hine.

University of Nebraska, Lincoln.

LIST OF ORTHOPTERA COLLECTED IN GUATEMALA BY C. C. DEAM AND E. B. WILLIAMSON.

A. N. CAUDELL.

Tryxalis brevicornis Linn., one female.
Orphulella neglecta Rehn, two males and two females.
Orphulella punctata DeGeer, three females.
Heliastus guatemalae Sauss., two males and two females.
Heliastus sumicrasti Sauss., three males and two females.
Osmilia tolteca Sauss., one male and three females.
Schistocerca vaga Scudder, one female.

Besides the above adult forms, there are six young nymphs of a species of Dictyophorus, thirteen nymphs of Heliastus, and one young locustian nymph.

Washington, D. C.

KEY TO THE FAMILIES OF OHIO LICHENS.

J. C. HAMBLETON.

1. Fruiting thallus with apothecia or perithecia containing asci; Ascomycetes living symbiotically with algae. ASCOLICHENES. 2.
1. Fruiting thallus not with apothecia nor perithecia; spores produced on basidia; Basidiomycetes living symbiotically with algae. BASIDIOLICHENES. 3.
2. Fruiting body an apothecium. DISCOLICHENES. 4.
2. Fruiting body a perithecium. PYRENOLICHENES. 23.
3. Hymenium on an exposed surface. (none in our territory. HYMENOLICHENES.
3. Hymenium lining closed cavities (none in our territory). GASTROLICHENES.
4. Paraphyses forming a powdery mass with the spores; disc of apothecium more or less open. The paraphyses growing beyond the asci forming there a network, adhering to the disc of the apothecium which soon breaks up into a powdery mass with the spores; Algae belonging to the Chlorophyceae. CONYOCARPALES. 5.
4. Paraphyses not forming a powdery mass with the spores. 6.
5. Apothecia borne on a stipe, exciple without algae; thallus crustaceous or hypophloedal, without cortical layer CALICIACEAE.
5. Apothecia sessile; exciple with algae. CYPHELIACEAE.
6. Disc of apothecium lineal, elipsoid, or somewhat angular; algae belonging to Chlorophyceae. GRAPHIDALES. 7.
6. Disc of apothecium circular. Algae belonging Chlorophyceae or Cyanophyceae. CYCLOCARPALES. 8.
7. Apothecia without border. ARTHONIACEAE.
7. Apothecia with border. GRAPHIDACEAE.
8. Spores uniseptate. 9.
8. Spores one-celled, multiseptate, or muriform, colorless or sometimes brownish; cell walls always thin. 11.
9. Spores colorless; thallus foliose or fruitcose, with cortical layer. THELOSCHISTACEAE.
9. Spores brown or dark. 10.
10. Thallus foliose or furticose, with cortical layer; pycnidia endobasidial. PHYSIACEAE.

10. Thallus crustaceous, ovate or lobed at the border, without cortical layer; pycnidia exobasidial. BUELLIACEAE.
11. Thallus when moist, more or less gelatinous, usually unstratified, scaly, foliose or fruticose, seldom crustaceous; apothecia sessile; alga a Nostoc. COLLEMACEAE.
11. Thallus when moist not gelatinous nor swollen. 12.
12. Thallus crustaceous, border lobed, horizontal. 13.
12. Thallus squamulose or foliose, horizontal or with border elevated; fastened to the substratum with rhizoids or umbilicus; pseudoparenchymatous throughout, or with cortical layer above or on both sides. 19.
12. Thallus cylindrical or fruitcose, upright or pendant; fastened to substratum with an anchor disc, or dying off from the ground growing radially; entirely covered with cortical layer. USNEACEAE.
13. Thallus with algae belonging to Chroolepus or Phylactidium. 14.
13. Thallus with algae belonging to Pleurococcus or Palmella. 15.
14. Exciple usually without algae, rarely rudimentary or wanting. LECANACTIDACEAE.
14. Exciple with algae always present; apothecia single or in groups sunken in thalline warts. THELOTREMACEAE.
15. Ascus one to eight spored, seldom sixteen to thirty-two; apothecia with distinct border or margin. 16,
15. Ascus many spored. ACAROSPORACEAE.
16. Exciple without algae. 17.
16. Exciple with algae; apothecia lecanorine. 18.
17. Apothecia sessile. LECIDEACEAE.
17. Apothecia borne on a stipe. CLADONIACEAE.
18. Apothecia sessile; border distinct. LECANORACEAE.
18. Apothecia single or in gropus, sunken in thalline warts; border usually very small. PERTUSARIACEAE.
19. Apothecia in young stage or always with the entire under side buried in the thallus; without margin, or bordered with the remains of the old covering. PELTIGERACEAE.
19. Apothecia on well defined stipes which are often strongly expanded and branched; naked or covered with thalline scales. CLADONIACEAE.
19. Apothecia sessile or short stalked; margin distinct. 20.
20. Interior hyphal layer wanting or indistinct; thallus entirely or in great part pseudoparenchymatous, with algae belonging Scytonema; pycnidia exobasidial. HEPPIACEAE.
20. Interior hyphal layer distinct in the well stratified thallus. 21.
21. Spores more or less spindle form, multiseptate, colorless or brownish; under side of thallus with abundant cyphellae or pseudocyphellae. STICTACEAE.
21. Spores ovate ellipsoid, or long ovate, one-celled (by exception two-celled), or muriform, in which latter case they are dark colored; cyphellae never present. 22.
22. Thallus with algae belonging to Scytonema. PANNARIACEAE.
22. Thallus always with algae belonging to Pleurococcus or Palmella apothecia sessile with algae in exciple. PARMELIACEAE.
23. Cavity of perichecium simple; not divided by complete or incomplete partitions. 24.
23. Cavity of pertithcium divided by complete or incomplete partitions; algae, Palmella or Chroolepus. MYCOPORACEAE.
24. Thallus foliose or scaly, with cortical layer on both sides or on upper side only; algae Pleurococcus of Palmella. DERMATOCARPACEAE.
24. Thallus crustaceous, without cortical layer or with amorphous cortex made up of horizontal hyphae. 25.

25. Perithecia inclined or horizontal, the ostioles usually opening into a common canal; situated in a stroma; algal cells Chroolepus. ASTROTHELIACEAE.
25. Perithecia erect with a single ostiole at the summit. 26.
26. Perithecia in a stroma; algal cells belonging to Chroolepus. TRYPETHELIACEAE.
26. Perithecia single; storma wanting. 27.
27. Spores one-celled (in our species); algae belonging to Pleurococcus or Palmella. VERUCARIACEAE.
27. Spores one to multiseptate (in our species); algal cells belonging to Chroolepus. PYRENULACEAE.

PUBESCENCE AND OTHER EXTERNAL PECULIARITIES OF OHIO PLANTS.

EDNA M. MCCLEERY.

In this study of the protective coverings and other peculiarities of the leaves and twigs of Ohio plants, the entire state herbarium has been examined and the plants classified under the following heads:

1. Pubescent—(a) glandular, (b) stellate, (c) tomentose;
2. Glabrous;
3. Glaucous;
4. Granular;
5. Scurfy;
6. Resin dotted, punctate, peltate scales.

In some cases it has been difficult to classify certain species on account of many of the forms merging almost imperceptibly from one to another. This is noticeable especially in pubescent and tomentose forms. In other cases the difficulty in classification has come from the change which takes place during development from the young to the mature condition.

In Salix candida, for instance, the leaves are loosely tomentose when young, but become glabrate above when mature. In Quercus nana the leaves are stellate pubescent above when young but become glabrous when mature, while in Quercus minor the young twigs are tomentulose but the mature ones glabrous. In all cases of this kind the forms have been listed under two or more heads.

The entire number of reported Ohio vascular plants is about 2200. Of these about 2125 are angiosperms, 10 gymnospermes, and 70 pteridophytes. 904 plants were found to be pubescent. This includes all degrees and varities of pubescence from those with only a soft fine pubescence like the clover and Oxalis to those with heavy hairs like the nettles or thistles. For a dense velvety pubescence of both twigs and leaves Althaea officinalis might be examined; for hirsute pubescence of both twigs and leaves Asclepias tuberosa is a good example; for soft downy pubescence

Phlox pilosa; for appressed pūbescent leaves Hydrophyllum virginicum; for ciliate leaves Valeriana sylvatica.

Only 37 of the 904 pubescent plants are stellate-pubescent, but these are very striking. The butternut, Juglans cinerea, has stellate pubescent leaves, and also four of the oaks; Quercus nana, Quercus marylandica, Quercus minor and Quercus prinoides. The most pronounced of this type, however, are the two crotons, Croton capitatus and Croton monanthogynus.

Of the glandular pubescent forms there are 58. Many plants have stems of this type without having the leaves to correspond. About half of the roses, as well as Rhexia virginica and Scutellaria cordifolia have glandular hairs on the stems. One of the most striking forms in the plant kingdom, the Drosera or sundew, belongs to this group.

There are 67 tomentose forms but all of them are not constant throughout their whole life. About one-half of those which are tomentose when young become either glabrous, glabrate or slighlty pubescent when mature. Many of the oaks, among them Quercus platanoides, and Quercus minor, are densely tomentose on the under side of the leaves. The young twigs of Quercus minor are also tomentose. Viburnum alnifolium is interesting in being one of the few which is stellate-tomentose.

532 plants were found to be entirely glabrous, that is, having both sides of the leaves and the twigs entirely free from hairs throughout their whole life; but 1019 were found to have one or more glabrous parts. The spring beauty, Claytonia virginica, and wake-robin, Trillium grandiflorum, are common examples of the former; Cercis canadensis and Aster laevis of the latter.

Of the glaucous forms there are 59. The glaucous bloom of twigs and leaves is identical with that on some fruit, such as plums and grapes, but that on leaves is not usually so noticeable. It may be seen on the under side of the leaves of Salix glaucophylla and Salix myrtilloides, and on the stems of Vitis bicolor and Helianthus grosseserratus.

The granular and scurfy forms are comparatively few in number, only about 24 of the former, and 34 of the latter. The upper surfaces of the leaves of Silene armeria and of Amaranthus blitoides are granular. All of the chenopods are scurfy.

This leaves only those which are resin-dotted, punctate, or have peltate scales. There are 106 in the division, and it is perhaps the most interesting group of all. Beautiful peltate scales are found on Hicoria minima and on Chamaedaphne calyculata. Resin-dots are found on many, among them being Ribes floridum, Gaylussacia resinosa and Glecoma hedercacea. The most strikingly punctate are the polygonums and the hypericums.

MEETING OF THE BIOLOGICAL CLUB.

BOTANICAL HALL, October 2, 1906.

The Club was called to order by the President, Mr. Griggs. The minutes of the previous meeting were read and approved.

The program of the evening consisted of reports of the summer's work by the members. Prof. Osborn reported on the work carried on at the Lake Laboratory. Especially the work of Prof. Rice on the bird fauna of the Point, and Prof. Walton on the Protozoa and Annelids. Prof. Schaffner spent his summer in Kansas working on the flora of that region. While at work there he noticed a case of mutation in Verbena stricta. The normal flowers of this Verbena are colored a purplish blue; but the mutants were a whitish pink, and were found covering an area of about one square mile, being mixed with the native blue form. Prof. Hine spent the greater part of the summer at the Gulf Biologic Station in the interest of the Crop Pest Commission. He reported that as yet no remedy had been discovered for the Cotton Boll Weevil, as a result it is spreading rapidly eastward and northward; and at last reports was within thirty miles of the Mississippi River. Prof. Ball reported that the Codling Moth and the Grasshopper cause a million dollars worth of damage annually in Utah. A Leaf Hopper that works on the sugar beet caused an estimated damage of seven hundred and fifty thousand dollars last year, while this year it caused practically no damage at all. Prof. Griggs reported on the fruiting habits of Bidens beckii, which he observed at Cedar Point. Bidens beckii which is an aquatic develops a seed provided with five barbed spines which are about an inch long.

Prof. Osborn, Prof. Hine and Prof. Schaffner were appointed on a committee to nominate officers for the ensuing year.

Prof. Osborn, Prof. Landacre and Mr. Metcalf were appointed on a committee to formulate a plan for entertaining the Ohio Academy of Science at its Thanksgiving Meeting in Columbus.

Z. P. METCALF, Secretary.

Date of Publication of December Number, December 13, 1906.

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seums, high schools, or township schools of the state as may be willing to pay the cost of labelling and transporting such specimens, and furnish evidence that such collections will be duly preserved and made available for the use of students and others interested. Preference is to be given in order of application to high schools offering courses in nature study, Zoology or Botany, and so located that no other collections of a similar nature are available for study and demonstration.

SECTION 5. The Director of said Survey shall make on or before the first of February of each year, a report to the Governor covering the work of the preceding year and the report shall be transmitted to the General Assembly to be printed in the same manner as other public documents or as shall be otherwise ordered. The special papers and reports prepared in pursuance of the objects of the Survey shall be submitted for publication to the Supervisor of printing and shall be printed and issued under the same regulations as are in force for publications of the Geological Survey.

SECTION 6. The compensation of the Director of said Survey shall be at the rate of $200 per month for the time actually employed. The compensation of specialists and assistants shall be fixed by the Director. The said salaries together with the traveling and incidental expenses shall be paid monthly on the presentation of properly itemized vouchers signed by the Governor out of the State Treasury from the appropriations made for such purposes.

SECTION 7. There is hereby appropriated from the general revenue fund the sum of five thousand dollars annually for the purpose above named.

SECTION 8. This act shall take effect and be in force from and after its passage.

The Ohio Naturalist,

PUBLISHED BY

The Biological Club of the Ohio State University.

Volume IX. NOVEMBER, 1908. No. 1.

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THE CENTROSOMES OF MARCHANTIA POLYMORPHA.*

JOHN H. SCHAFFNER.

Since Ikeno reported the presence of centrosomes in the antheridial cells of Marchantia polymorpha, in 1903 and 1904, his results have been disputed by several investigators. Ikeno found centrosomes at the poles of the spindle in all the generations of antheridial cells and also observed that these bodies are at the poles of the last division spindle, where they begin to be transformed into the bodies, the so-called blepharoplasts, from which the flagella of the spermatozoid are developed. He came to the same conclusion, therefore, as Belajeff had several years before, through his studies on Gymnogramme and Marsilea, that the blepharoplast is a centrosome.

Miyake, in 1905, failed to see centrosome-like bodies at the poles of the division spindle of the antheridial cells of Marchantia except in the last division, i. e., in the spermatozoid mother cells. From this negative evidence he concludes that Marchantia has no centrosomes. He says: "But my present study seems to show that there is no true centrosome at least in the Hepaticeae, agreeing with the conclusion of the recent study of Gregoire and Bergh. The centrosome hitherto reported in the cells of the Hepaticeae are nothing but a center of cytoplasmic radiation." It is difficult to imagine how one is to distinguish between "true centrosomes" and "centres of cytoplasmic radiation," especially when the bodies in question are situated at the poles of the spindle.

Ikeno, in reply to Miyake, firmly maintains his former position as follows: "Notwithstanding the contrary statement of Miyake, I have no doubt about the real existence of the

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*Contributions from the Botanical Laboratory of Ohio State University, XXXVII.

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The Ohio Naturalist,

PUBLISHED BY

The Biological Club of the Ohio State University.

Volume VIII. MAY, 1908. No. 7.

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TYPE AND VARIABILITY IN THE ANNUAL WOOD-INCREMENT OF ACER RUBRUM L.

ALFRED DACHNOWSKI.

In all temperate zones, at least, trees form annually one layer of wood, which appears on a cross-section of a tree as a ring, more or less clearly defined. The rate at which the diameter and the area of any cross-section of the tree increases, can therefore be easily ascertained by measuring the width of the rings. To obtain direct evidence as to the relation of the rate of wood formation to the nature of the habitat, and to obtain information on the value of a biometric study in differentiating such habitats, statistical work has been carried out during the past winter of 1907-8. The work was done in connection with an inquiry on the toxic properties of bogwater and bogsoils, the data of which, correlated with this and other studies, will be brought out elsewhere in another paper.

The purpose of the article here briefed is to call attention to the fact that statistical methods first used by Galton and now applied by Pearson (7), Davenport (4), Shull (8), and others to the more complicated questions in variation and heredity, may be of service also in Forestry problems as well as in questions of Ecology.

About 25 miles east of Columbus occurs an extensive lake, approximately ten miles long and one mile wide, known as Buckeye Lake. Near the northern bank, and midway between the small towns of Lakeside and Avondale is a bog-island very nearly one-tenth the dimensions of the lake. Soundings made to determine the character of the peat gave 30 to 40 feet as the depth of the island. Its vegetation presents two well-marked zones,—a central one consisting of Sphagnum, Carex, Eriophorum, Oxycoccus, Drosera, Rhus vernix, Aronia nigra, and others, and a marginal zone which includes besides several species of Salix, Alnus incana, A. rugosa, Ilex verticillata, Cornus

The shores of ponds, lakes, and oceans have been the subject of ecological studies to a greater extent than has any other physiographic region. This is, no doubt, due to the concentration in a small space of many different plant formations with the developmental stages exceptionally well defined. Studies of this sort of particular interest with respect to the ecology of Cedar Point, being physiographically quite similar as to the areas embraced, are those of MacMillan at the Lake of the Woods,[2] Cowles at the southern end of Lake Michigan,[3] Ganong at the Miscou Beach,[4] and Kearney at the Great Dismal Swamp,[5] and at Ocracoke Island.[6]

As referred to in the present article an association of species occupying a definite, more or less homogeneous unit of ecological environment (habitat), is termed an ecological plant *formation*. The formation is the unit of vegetation and is always characterized by one or more dominant species which are termed the *facies*. The facies may appear separately from each other, each having a definite association of accompanying species, and where this happens the facies thus characterize as many different *consocies*. Certain species in the formation may become very conspicuous at certain periods in the season (*aspects*), such species being termed *principal species* and the associations which they thus characterize, *societies*. The aggregation of the common descendants of a plant constitutes an ecological *family* and the aggregation of several families an ecological *community*.

All plant formations bring about reactions of various kinds in the habitat,—removal of plant foods, accumulation of vegetable debris, cutting off the light, etc.,—which usually result in making the habitat less suitable to the resident species but better suited to other species which, by *invasion* of the altered habitat, may eventually occupy it to the complete exclusion of the species of the original formation. Invasion consists (first) of *migration*, by which is meant the entrance into the habitat of disseminules of various sorts (seeds, spores, vegetative shoots, etc.), and (second) of *ecesis*, by which is meant the germination, growth, and establishment of the migrant disseminule.

---

[2] MacMillan, Conway. Observations on the Distribution of Plants along Shore of Lake of the Woods. Minnesota Botanical Studies. Geol. and Nat. Hist. Survey Minn. Bulletin 9 : 949-1023. 1897.

[3] Cowles, H. C. The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan. Bot. Gaz. 27 : 95-117, 167-202, 281-303, and 361-391. Feb., Mar., Apr., and May, 1899.

Also the Physiographic Ecology of Chicago and Vicinity. Bot. Gaz. 31 : 73-108, 145-182. Feb. and Mar., 1901.

[4] Ganong, W. F. The Nascent Forest of the Miscou Beach Plain. Bot. Gaz. 42 : 85-87. 1906.

[5] Kearney, T. H. A Report on a Botanical Survey of the Dismal Swamp Region. Contr. Nat. Herb. 5 : 367-395. 1901.

[6] Kearney, T. H. The Plant Covering of Ocracoke Island. Contr. Nat. Herb. 5 : 275–284. 1900.

With the appearance of a new habitat, such as the elevation of a new land area, the initial formations will be *open*, i. e., not occupying the whole area; but, with successive changes in the habitat, often determined largely by reactions caused by the vegetation itself, the formations will become *closed*, and *competition* between the various species may become severe. From the *initial stages* the vegetation of a habitat will thus normally pass through a varying number of *intermediate stages* to an *ultimate* or *climax stage* in which the vegetation has reached a more or less permanent condition, termed *stabilization*.[7] Recent investigations have added considerably to our knowledge regarding competition between various species of plants and this has an important bearing upon the subject of succession between the various formations. It has been found that many plants throw off, or at least cause to be present in the soil certain substances toxic to themselves, to certain other plants, or to both.[8] Such phenomena alone could account for many ecological successions.

The ecological classification of the vegetation of a region is usually very intimately correlated with the physiography of that region, and the development of the vegetation through the successive stages of a succession is very often definitely determined by the corresponding land forms occurring in the physiographic development of the region. To this statement Cedar Point is no exception and the excellent work of Moseley in tracing the physiographic development of Cedar Point and Sandusky Bay is of great service to the student of the ecology of this region, in affording a foundation upon which to base an ecological classification of the vegetation. As a matter of fact, Prof. Moseley's publication includes much botanical matter directly in the line of an ecological classification, especially with reference to the vegetation of the sand ridges of the peninsula.[9]

The writer's extended investigations of the ecology of the peninsula of Presque Isle at Erie, Pennsylvania, during the last three years, and now in the course of publication, has led to a much better understanding of certain vegetational phenomena on Cedar Point. Presque Isle is considerably larger than Cedar

---

[7] For an extended discussion of the various ecological processes and vegetational structures the reader is referred to Research Methods in Ecology, by F. E. Clements, Lincoln, Nebraska. 1905. In the present contribution the writer has followed Clements' terminology so far as technical terms have been used.

[8] Livingston, B. E., Britton, J. C., and Reid, F. R. Studies on Properties of Unproductive Soils. U. S. Dept. Agr., Bureau of Soils, Bull. 28 : 1–39. 1905. Also Livingston, B. E., assisted by Jensen, C. A., Breazeale, J. F., Pember, F. R., and Skinner, J. J. Further Studies on the Properties of Unproductive Soils. U. S. Dept. Agr., Bureau of Soils, Bull. 36 : 1–71. 1907.

[9] Moseley, E. L. Formation of Sandusky Bay and Cedar Point. Proc. Ohio State Acad. Science. Thirteenth Ann. Rpt. 4 : 179–238. June 15, 1905.

Point, the vegetation is almost entirely in its natural state, free from human interference, and some of the successions present a remarkably complete series of stages, whereas Cedar Point presents, in many cases, a fragmentary series considerably disturbed by man's activities.

With this explanation the writer in this contribution may, perhaps, be pardoned for frequent comparative references to the vegetation of Presque Isle. Although often differing considerably as to particulars, Presque Isle and Cedar Point have much in common, both with reference to the general physiographic development of the peninsulas and to the ecological classification of their vegetation.

The best method of treatment of the structure of the vegetation of any particular locality is, to be sure, more or less dependent upon the completeness of the successions. If the various stages of the successions are present it is most logical to use the developmental method, taking up the various stages in the order of their development and considering the vegetation as a gradual growth or evolution from the simple initial stages to the more complex stages tending towards stabilization.

The vegetation of Cedar Point will be discussed in this paper according to the developmental method, as many of the successional stages are exemplified, or at least indicated, in the present vegetation, while correlations with certain similar structures on Presque Isle will indicate the probable composition of certain missing stages.

The following classification is here presented as a provisional outline of the vegetational structures on Cedar Point. Wherever the same structure has been recognized both here and on Presque Isle the same nomenclature has been adopted as was used in the author's forthcoming work on the ecology of Presque Isle.

A—The Cottonwood Bar-Ridge-Thicket-Forest Succession.
  a—The *Populus-Salix* Dune Formation,
  b—The *Andropogon* Dune Formation,
  c—The *Toxicodendron* Thicket Formation,
  d—The *Pinus-Juniperus* Forest Formation,
  e—The *Quercus velutina-imbricaria* Forest Formation,
  f—The *Ulmus-Acer* Forest Formation.

B—The Lagoon-Marsh-Wet Meadow-Thicket-Forest Succession.
  a—The *Potamogeton* Formation, and
    The *Populus-Salix* Formation.
  b—The *Potamogeton* Formation, and
    The *Juncus-Eleocharis* Formation, and
    The *Populus-Salix* Formation.
  c—The *Potamogeton* Formation, and
    The *Typha-Scirpus* Formation, and
    The *Salix spp.* Formation, and
    The *Populus-Salix* Formation.

- d—The *Potamogeton* Formation, and
  The *Castalia-Nymphaea* Formation, and
  The *Decodon-Persicaria* Formation, and
  The *Cephalanthus-Cornus* Formation, and
  The *Rhus-hirta* Formation, and
  The *Ulmus-Acer* Forest Formation.

C—The Beach-Sand Plain-Thicket-Forest Succession.
- a—The Lower Beach...The *Chlamydomonas* Formation,
- b—The Drift Beach.....The *Cakile-Xanthium* Formation,
- c—The Sand Plain ....The *Artemisia-Panicum* Formation,
- d—The *Rhus-Prunus-Toxicodendron* Thicket Formation,
- e—The *Quercus velutina-imbricaria* Forest Formation.

D—The Beach-Sand Plain-Heath-Forest Succession.
- a—The Lower Beach...The *Chlamydomonas* Formation,
- b—The Drift Beach.....The *Cakile-Xanthium* Formation,
- c—The Sand Plain........The *Artemisia-Panicum* Formation,
- d—The Heath.........The *Arctostaphylos-Juniperus* Heath Formation,
- e—The *Quercus velutina-imbricaria* Forest Formation.

E—The Dune and Blowout Successions.
- a—The *Ammophila* Fringing-Dune Formation,
- b—The *Elymus Dune* Formation, or
  The *Andropogon* Dune Formation,
- c—The *Prunus-Rhus* Dune Thicket Formation, or
  The *Arctostaphylos-Juniperus* Heath Formation.

- a—The *Artemisia-Panicum* Blowout Formation,
- b—The *Arctostaphylos–Juniperus* Heath Formation.
  (The Secondary *Catalpa* Blowout Formation).

F.—The Bay-Marsh-Wet Meadow-Thicket-Forest Succession.

A. The Beach Habitat.
- a—Same as under the Beach-Sand Plain-Thicket-Forest Succession.

B. The Marsh Habitat.
- a—The *Scirpus* Formation,
- b—The *Phragmites-Typha* Marsh Formation,
- c—The *Salix discolor-lucida* Thicket Formation, or
  The *Calamagrostis canadensis* Wet Meadow Formation,
- d—The *Rhus hirta* Thicket Formation,
- e—The *Ulmus-Acer* Forest Formation.

C. The Cove Habitat.
- a— (The *Chara* Formation),
- b—The *Potamogeton* Formation,
- c—The *Castalia-Nymphaea* Formation,
- d—The *Phragmites-Typha* Marsh Formation,
- e—The *Calamagrostis canadensis* Wet Meadow Formation,

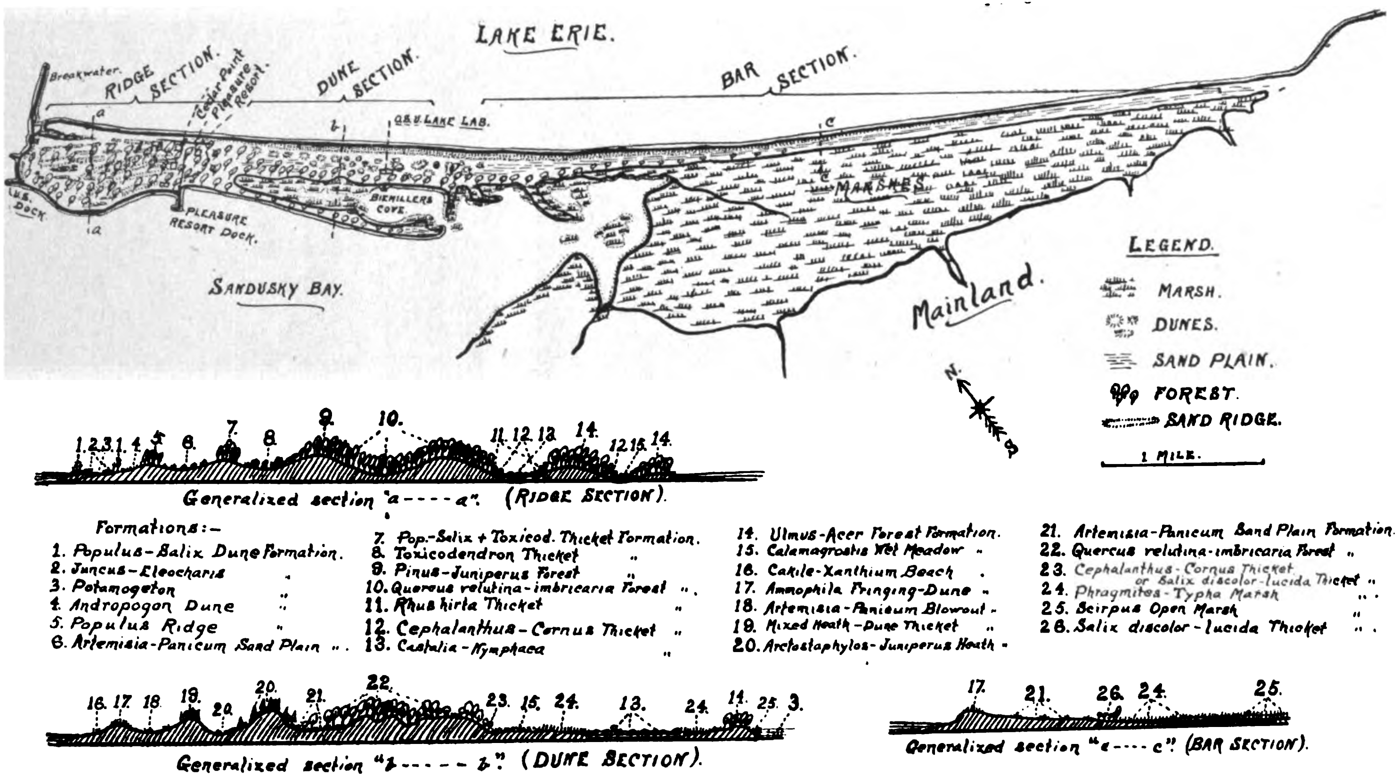
LAKE ERIE.
Breakwater.
RIDGE SECTION.
Cedar Point Pleasure Resort.
DUNE SECTION.
BAR SECTION.
O.S.U. LAKE LAB.
a
b
c
U.S. DOCK.
PLEASURE RESORT DOCK.
BIEMILLERS COVE.
SANDUSKY BAY.
MARSHES.
Mainland.
N.
S.
LEGEND.
MARSH.
DUNES.
SAND PLAIN.
FOREST.
SAND RIDGE.
1 MILE.
Generalized section "a - - - - a". (RIDGE SECTION).
Formations:–
1. Populus-Salix Dune Formation.
2. Juncus-Eleocharis "
3. Potamogeton "
4. Andropogon Dune "
5. Populus Ridge "
6. Artemisia-Panicum Sand Plain "
7. Pop.-Salix + Toxicod. Thicket Formation.
8. Toxicodendron Thicket "
9. Pinus-Juniperus Forest "
10. Quercus velutina-imbricaria Forest "
11. Rhus hirta Thicket "
12. Cephalanthus-Cornus Thicket "
13. Castalia-Nymphaea "
14. Ulmus-Acer Forest Formation.
15. Calamagrostis Wet Meadow "
16. Cakile-Xanthium Beach "
17. Ammophila Fringing-Dune "
18. Artemisia-Panicum Blowout "
19. Mixed Heath-Dune Thicket "
20. Arctostaphylos-Juniperus Heath "
21. Artemisia-Panicum Sand Plain Formation.
22. Quercus velutina-imbricaria Forest "
23. Cephalanthus-Cornus Thicket or Salix discolor-lucida Thicket "
24. Phragmites-Typha Marsh "
25. Scirpus Open Marsh "
26. Salix discolor-lucida Thicket "
Generalized section "b - - - - - b". (DUNE SECTION).
Generalized section "c - - - - c". (BAR SECTION).

Fig. 1. Generalized ecological map and transects of Cedar Point. The width of the peninsula is relatively exaggerated to better show the vegetational features, and the finer topographic features are only approximately correct. For more accurate details of topography see Moseley's contribution and the U. S. Geolo. Survey Topographic Map.

f—The *Cephalanthus-Cornus* Thicket Formation,
g—The *Rhus hirta* Thicket Formation,
h—The *Ulmus-Acer* Forest Formation.
(The Anomalous *Ailanthus* Forest Formation).

THE COTTONWOOD BAR-RIDGE-THICKET-FOREST SUCCESSION.

As Prof. Moseley has so well shown, the terminal portion of Cedar Point, termed the Ridge Section, consists mainly of a series of sand ridges initiated by northeast gales during times of high water in Lake Erie, and subsequently built up to their present dimensions by the combined action of wind and vegetation in accumulating the loose beach sand. The approximate dates of formation of the ridges are shown to run consecutively from about 1429 A. D. for the oldest ridge, on the Bay side of the peninsula, to 1899 for the youngest ridge along the Lake front.

Beginning, therefore, with the present Lake Erie beach of the Ridge Section, the vegetation may be discussed from the developmental standpoint from the youngest to the older stages of the succession, the various stages being found in connection with similar physiographic units (sand ridges and intervening depressions) of consecutively older formation.

During a northeast gale, with high water in the Lake, the loose beach sand may be piled up into a bar which, upon the subsidence of the waves, will be left more or less permanently above the ordinary water level. Behind this bar there will be a more or less completely segregated lagoon. Into such a beach lagoon there will be blown during late spring many willow and cottonwood disseminules, which, floating upon the surface of the water, will soon be deposited and buried in the loose, wet sand which rapidly accumulates around the banks of the newly formed lagoon. Here the disseminules will sprout and the lagoon will soon be bordered by a zone of little cottonwoods and willows. The lagoon may be so narrow as to be completely filled up by the drifting sand before other vegetation may be able to establish itself, or, if the lagoon be wider, other vegetation may become established only to be later buried under the sand and killed. In either case, however, a sand rigde has been initiated by the establishment of the zone of cottonwoods and willows.

With the growth of the cottonwoods and willows there is offered an obstruction to the drifting sand, the height of the obstruction by its continued vertical growth tending to build the ridge ever higher. Cottonwoods will continue to grow vigorously under such conditions, providing the tops of the plants are not entirely buried. On Presque Isle the writer found cottonwoods buried to a depth of nearly 30 feet and still vigorously growing. As the lower branches of the tree become buried in the sand they die, although for a long time serving the purpose of sand binders, and numerous roots are sent out from all portions of the buried trunk.

The initial stage of the succession under discussion may be designated as follows:

The *Populus-Salix* Dune Formation.
Facies: *Populus deltoides*,
Salix cordata (?).
Secondary Species:

Cakile edentula,	*Salix interior*,
	Ammophila edentula.

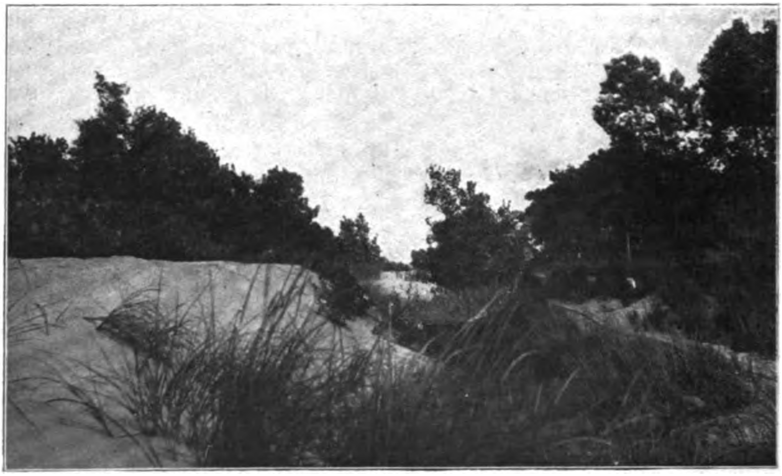

FIG. 2. Looking southward along the west side of sand ridge between the summer cottages and Lake Erie, north of the Breakers Hotel. Note the *Populus* forming the backbone of the ridge and the *Ammophila* and *Salix* being rapidly buried.

The rapidly growing ridge along the Lake front north of the Breakers Hotel is a fine example of the young stage of this formation. (Ridge No. 8, Moseley). With the vertical growth of the ridge the willows are soon buried and then probably the cottonwoods alone will not be able to offer a sufficient obstruction to the sand to cause further vertical growth of the ridge. In fact the branches immediately above the top of the ridge may die and the sand, being thus exposed to the action of the wind, may be again blown away. Generally, however, there appears another plant which, to a certain degree, takes the place of the lower limbs of the cottonwoods or, upon the death of the trees, may itself preserve the integrity of the ridge. The vegetational structure at this stage may be termed as follows:

The *Andropogon* Dune Formation.

Facies: *Andropogon furcatus.*

Secondary Species:
Artemisia caudata,
Andropogon scoparius,
Panicum virgatum.

The development of this formation on Cedar Point is far inferior to its development at Presque Isle. On Cedar Point the formation is usually more or less mixed with the foregoing formation, as in parts of Ridge 7, and later passes into the following structure:

The *Toxicodendron* Thicket Formation.

Facies: *Toxicodendron pubescens.*

Secondary Species:
Populus deltoides,
Parthenocissus quinquefolia,
Quercus velutina,
Salix amygdaloides,
Ptelea trifoliata,
Poa compressa,
Celastrus scandens,
Rhus aromatica,
Fraxinus americana,
Vitis vulpina,
Andropogon furcatus,
Juniperus virginiana.

This formation is characterized by several lianas or semilianas, which, together with young trees of several species, constitute a more or less definite thicket formation above which stand the older cottonwoods. The last named species is here probably best regarded as a relict of the earlier formations. The *Toxicodendron* Thicket Formation is best exemplified on Ridges 6(1) and 6(2), (Moseley).

The *Pinus-Juniperus* Forest Formation.

Facies: *Juniperus virginiana,*
Pinus strobus.

Principal Species: *Vagnera stellata.*

Secondary Species:
Quercus velutina,
Toxicodendron pubescens,
Populus deltoides,
Fraxinus biltmoreana,
Platanus occidentalis,
Opuntia humifusa,
Celastrus scandens,
Asclepias tuberosa,
Prunus serotina,
Panicum scribnerianum,
Equisetum robustum.
Quercus imbricaria,
Tilia americana,
Fraxinus americana,
Salix amygdaloides,
Ulmus fulva,
Cyperus schweinitzii,
Rubus procumbens,
Arabis laevigata,
Rhus aromatica,
Smilax herbacea,

The exact status of this formation is not easy to determine with respect to its counterpart on Presque Isle, but it appears that the formation on Cedar Point is a sort of merging of what has been called two distinct formations on Presque Isle. The formation is typically exemplified on Ridges 5 and 4 and, in places, on 3.

No alternation is evident between the facies of this formation, but there is, however, a distinct layering; the following layers being evident:

1. Primary Layer.—The facies and other trees of larger size.
2. Secondary Layer.—Young trees, mainly of same species as the facies but relatively larger numbers of oaks.
3. Tertiary Layer.—Low shrubs and herbs; *Vagnera*, *Equisetum*, etc.
4. Ground Layer.—Represented very sparingly by occasional fleshy fungi, moulds, myxomycetes, etc.

The formation is characterized by one principal species constituting the *Vagnera stellata* Society. Also conspicuous community and family groups of *Equisetum*.

The *Quercus velutina-imbricaria* Forest Formation.

Facies: *Quercus velutina*,
Quercus imbricaria.

Principal Species: *Aralia nudiflora*,
Washingtonia claytoni.

Secondary Species:
Pinus strobus,
Tilia americana,
Prunus virginiana,
Smilax herbacea,
Rubus nigrobaccus,
Vitis vulpina,
Vagnera stellata,
Meibomia dillenii,
Galium circaezans,
Ulmus americana,
Monarda fistulosa,
Phryma leptostachya.
Juniperus virginiana,
Prunus serotina,
Fraxinus americana,
Toxicodendron pubescens,
Aralia racemosa,
Parthenocissus quinqefolia
Vagnera racemosa,
Lespedeza violacea,
Helianthus strumosus,
Solanum nigra,
Nabalus albus,

This formation is best shown towards the north ends of Ridges 3 and 2. The habitat, although originally a xerophytic one with a pure sand soil, has become more and more mesophytic. The water-containing and water-retaining powers of the soil have been much increased by the accumulation of about three inches of humus which acts as a mulch, and also the same general effect is brought about by the continual rise of the water table coincident with the cumulative rise of water in the Lake.

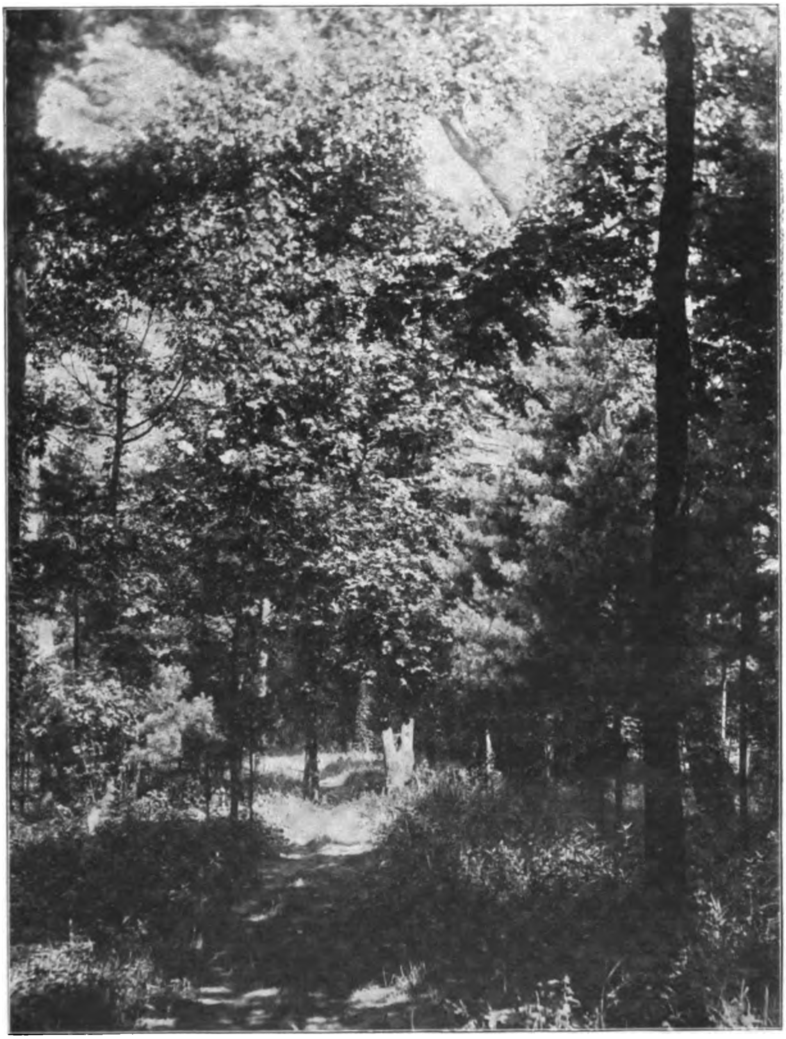

FIG. 3. Looking northwest along path from rear of Breakers Hotel, vegetation transitional into the *Pinus-Juniperus* Forest Formation. Note old cottonwoods, young pines, junipers, and oaks, and numerous lianas; also conspicuous tertiary layer.

This formation constitutes a forest habitat quite different in several respects from that of the preceding formation. The primary layer being deciduous, and, as a whole, being largely composed of species (oaks) coming into leaf rather late in the season, and, even then, not casting a dense shade, the relative amount of insolation reaching the lower layers in the oak forest is quite large; much larger than in the *Pinus-Juniperus* forest. Due in a large measure, probably, to this relatively greater amount of insolation there are developed in the oak forest much more pronounced layers. The following layers are there evident, aside from the Primary Layer the Shrub and Herbaceous Layers being most important:

1. Primary Layer.—Composed of the facies and other large trees.

2. Secondary Layer.—Younger individuals of the species constituting the primary layer, together with a very few large shrubs and small trees. Not a well defined structure in the formation as represented on Cedar Point.

3. Tertiary or Shrub Layer.—Composed of bushes and shrubs together with a tangle of lianas and certain tall herbaceous plants:

Rubus nigrobaccus,
Aralia racemosa,
Parthenocissus quinquefolia,
Nabalus albus,
Toxicodendron pubescens,
Agastache nepetoides,
Smilax herbacea,
Vitis vulpina,
Prunus virginiana,
Rhus aromatica,
Helianthus strumosus,
Steironema ciliatum,

4. Herbaceous Layer. Exhibiting more or less alternation with the Tertiary Layer and often grading imperceptibly into it, being at the same time of about equal importance with reference to the formational structure. This structure is very largely composed of herbaceous perennials with well developed underground stems, "Geophytes,"—Raunkiaer.[10]

Washingtonia claytoni,
Vagnera stellata,
Lespedeza violacea,
Galium triflorum,
Polygonum virginianum,
Salomonia commutata,
Aralia nudiflora,
Meibomia dillenii,
Galium circaezans,
Phyrma leptostachya,
Vagnera racemosa,
Monarda fistulosa.

5. The Ground Layer. This indefinite and variable layer is characterized by a few fungi and mosses living on the humus and dead leaves.

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[10] Raunkiaer, C. Types Biologiques pour la geographie botanique. Oversigt over det Kgl. Danske Videnskabernes Selskabs Forhandlinger, 1905 : 347–437.

Liberal translation into German by Dr. F. Fedde. In Aus de Natur. Oct. 1 & 15; Nov. 1 & 15; Dec. 1 & 15; 1907, and Jan. 1 & 15, 1908.

The *Ulmus-Acer* Forest Formation.

Facies: *Ulmus americana,*
Acer rubrum.

Secondary Species:
Fraxinus americana,
Quercus velutina,
Platanus occidentalis,
Sambucus canadensis,
Rubus nigrobaccus,
Parietaria pennsylvanica,
Lactuca floridana,
Helianthus decapetalus,
Solanum nigrum,
Boehmeria cylindrica,
Campanula americana,
Dryopteris spinulosa,
Fraxinus lanceolata.
Acer nigrum,
Ostrya virginiana,
Rubus occidentalis,
Ribes cynosbati,
Parthenocissus quinquefolia,
Impatiens biflora,
Phytolacca decandra.
Galium triflorum,
Botrychium virginianum,
Circaea lutetiana,
Eupatorium ageratoides.

The accumulation of humus in the soil of the ridge as well as the general rise of water in the Lake has brought about a gradual change towards mesophytic, or even hydrophytic, conditions so that this formation, as represented on Ridge No. 1, is practically the same as would be the formation derived upon the filling up of a hydrophytic pond or swamp by the accumulation of humus. In either case there is a rich humous soil with great capillarity and a high water table.

The formation as represented on Cedar Point is not of large area and it has, moreover, been much disturbed by man's activities, and no effort was made on the part of the writer to determine the minor formational structure.

THE LAGOON-MARSH-WET MEADOW-THICKET-FOREST SUCCESSION.

In the writer's studies on the ecology of Presque Isle there was found to be represented there a remarkable series of lagoons, these being evident in all stages from extreme youth to mature old age, so that the successive development of the lagoon vegetation was not difficult to decipher. On Cedar Point, however, the lagoons are few and the successional series is rather incomplete. Nevertheless, such stages as are in evidence show much similarity to corresponding stages on Presque Isle so that, by correlation, a fair idea may be gained of the probable structure of the lagoon vegetation for the missing stages.

For a lagoon or pond the normal tendency is to become filled with accumulating vegetable debris, the surrounding vegetation being arranged in concentric zones, each inner one more hydrophytic, and, with the accumulation of vegetable debris and the elevation of the respective habitats, there is a continual advance of all the zones towards the deeper central portion of the lagoon or pond. On Cedar Point, however, the elevation of the habitat of the various zones due to the accumulation of vegetable matter must to some degree be counteracted by the general rise of the water table consequent to the cumulative rise of water in Lake Erie,—2.14 feet per century. It seems likely that, in some cases at least, the general movement may be reversed as to the concentric vegetational formations, so that they may move away from the central portion of the depression; thus, from habitats more hydrophytic to less hydrophytic ones.

At the northeast corner of Cedar Point sand is rapidly accumulating along the shore to the south of the Jetty Protection or Breakwater and a lagoon is now (1907) being segregated from the Lake near the old light-house building. There is at this place a considerable indrifting of organic drift debris of various sorts so that the vegetation shows somewhat more of an affinity to that of a humus marsh or pond than is usual in beach lagoons. The initial stage here appears from the studies given it (1905–7) to be essentially as follows:

Stage A.

a. *Potamogeton* Formation.
b. *Populus-Salix* Formation.

The *Potamogeton* Formation.

Facies: *Potamogeton pectinatus.*
Secondary Species:
Vallisneria spiralis, *Potamogeton natans*, *etc.*

The *Populus-Salix* Formation.

Facies: *Populus deltoides*,
Salix cordata.
Secondary Species:
Salix fragilis (?), *Salix lucida*,
Cakile edentula, *Strophostyles helvola*,
Xanthium commune.

This latter formation may be considered as identical with the beginning of a *Populus-Salix* Ridge Formation but, under the conditions leading to the development of a sand ridge, the willows soon disappear while, under the more uniform conditions leading through the different stages of a lagoon succession, the willows are relatively quite important.

In the lagoon succession at Presque Isle the second stage shows the following structure, this appearing to be typical also for the Cedar Point succession, although somewhat mixed in the lagoon under discussion:

Stage B.

a. The *Potamogeton* Formation.
b. The *Juncus-Eleocharis* Formation.
c. The *Populus-Salix* Formation.

In the older part of this lagoon the *Potamogeton* Formation shows little change from its structure in the youngest part of the lagoon, excepting that the constituent plants are larger and more numerous. At the edge of the water and extending a few inches up onto the wet sand is a zone which may be termed:

The *Juncus-Eleocharis* Formation.

Facies: *Juncus balticus.*
Eleocharis intermedia.

Secondary Species:

Cyperus rivularis,	*Roripa palustris.*
Populus deltoides,	*Salix cordata,*
Salix lucida.	

There is but little change in the outer *Populus-Salix* zone in this stage, aside from the further growth of the individuals and the appearance of occasional ruderal species. In the oldest and most highly developed parts of the lagoon under consideration the vegetation is in the beginning of what may be termed Stage C, with the following structure:

Stage C.

a. The *Potamogeton* Formation.
b. The *Typha-Scirpus* Formation.
c. The *Salix* (*spp.*) Formation.
d. The *Populus-Salix* Formation.

In this stage there is again little change in the *Potamogeton* Formation, but in the shallow water near the shore, and also taking the place of the *Juncus-Eleocharis* Formation on the wet bank at the water's edge, there has appeared a new vegetational structure as follows:

The *Typha-Scirpus* Marsh Formation.

Facies: *Scirpus validus,*
Scirpus americanus,
Typha latifolia.

Secondary Species:

Sparganium eurycarpum,	*Juncus balticus,*
Eleocharis intermedia,	*Scirpus atrovirens,*
Sagittaria latifolia,	*Alisma plantago-aquatica,*
Roripa palustris,	*Potamogeton natans,*
Castalia tuberosa.	

Among the secondary species are a few, —*Alisma*, *Roripa*, *Sagittaria*,—which are more typically representative of the humus swamp or marsh margin than of a beach lagoon and their presence here is to be regarded as due to the rather large amount of organic matter (drift debris) incorporated into the soil of the habitat. The vegetation of this formation catches considerable sand and contributes quite appreciably to the filling of the lagoon.

The facies exhibit a distinct alternation in the *Typha-Scirpus* Formation. On the wet bank, and extending out into the water to a variable depth of about a foot, is the *Scirpus americanus* Consocies, alternating here and there with the *Typha latifolia* Consocies, while beginning in 6 or 8 inches of water and extending out into the deeper water of the lagoon, is the *Scirpus validus* Consocies, the latter thus forming a zone in the deeper part of the habitat. In this consocies *Castalia* is beginning to appear in a few places in the deepest part and, providing the marsh formation does not build up the soil and advance too rapidly, there may soon be initiated a new formation between the *Typha-Scirpus* Formation and the *Potamogeton* Formation.

In the upper part of the *Typha-Scirpus* Formation, and extending up to the outer *Populus-Salix* Formation, there is a zone the status of which was not satisfactorily determined. This zone has been provisionally designated as follows:

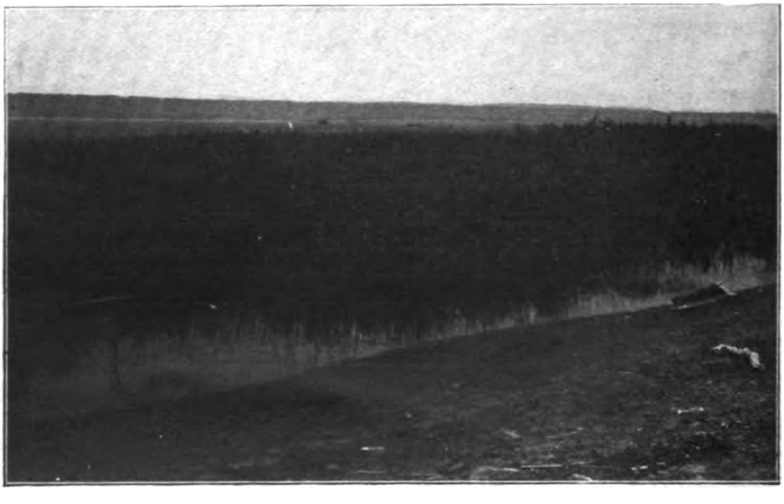

FIG. 4. Looking east across the new lagoon a few rods south of the Break-water. *Typha-Scirpus* Formation conspicuous. Lake in distance and bar visible just beyond the marsh vegetation. Young cottonwoods and willows in immediate foreground are submerged by unusually high water.

The *Salix* (*spp.*) Formation.

This structure probably represents a transitional condition the true status of which will become evident in the future. At present it consists of several species of *Salix* with scattering individuals of *Vitis vulpina*, *Bidens frondosa*, *Polygonum pennsylvanicum*, *Ambrosia trifida*, etc. The structure is evidently the beginning of a thicket formation similar in position to the *Myrica-Salix* thicket formation on Presque Isle.

Proceeding to the next oldest lagoon on Cedar Point we have the Lily Pond just to the west of the highest portion of Ridge No. 6. The present status of the vegetation around the pond is about that termed, for the succession on Presque Isle, stages "H" and "I". About the Lily Pond on Cedar Point the following general vegetational structure appears:

a. The *Potamogeton* Formation.
b. The *Castalia-Nymphaea* Formation.
c. The *Decodon-Persicaria* Formation.
d. The *Cephalanthus-Cornus* Thicket Formation.
e. The *Rhus hirta* Thicket Formation.
f. The *Ulmus-Acer* Forest Formation.

There should be in the deepest part of the pond a *Chara* Formation, but, for lack of the proper facilities for studying this vegetation this point was not determined. In similar ponds on Presque Isle there was evidence of a central *Chara* formation, although Pieters found in Lake St. Clair that this formation was usually scanty or entirely absent on a sandy bottom but present on a clay or alluvial bottom.[11]

The *Potamogeton* Formation.

This formation has here the following structure:

Facies: *Potamogeton pectinatus*,
Potamogeton natans.
Principal Species: *Utricularia vulgaris*.
Secondary Species:
Naias flexilis, *Vallisneria spiralis*,
Philotria canadensis, *Potamogeton sp.*

The *Castalia-Nymphaea* Formation.

This formation is perhaps relatively of more importance in the vegetational structure here than is the preceding formation: Its structure is essentially as follows:

Facies: *Castalia tuberosa*,
Nymphaea advena.
Secondary Species:
Potamogeton natans, *Philotria canadensis*,
Utricularia vulgaris, *Potamogeton sp.*,
Scirpus validus, *Decodon verticillatus*.

This formation, relatively among its competitors, is a rapid soil-former. The plants of the formation typically exhibit large rootstocks, which upon their decay contribute considerably to the accumulation of humus, while the tangled mass of petioles and leaves in and on the water not only catch much floating debris, but, upon their decay, also add to the humus beneath.

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[11] Pieters, A. J. The Plants of Lake St. Clair. Michigan Fish Commission Bull. 2 : 6 and 9. 1894.

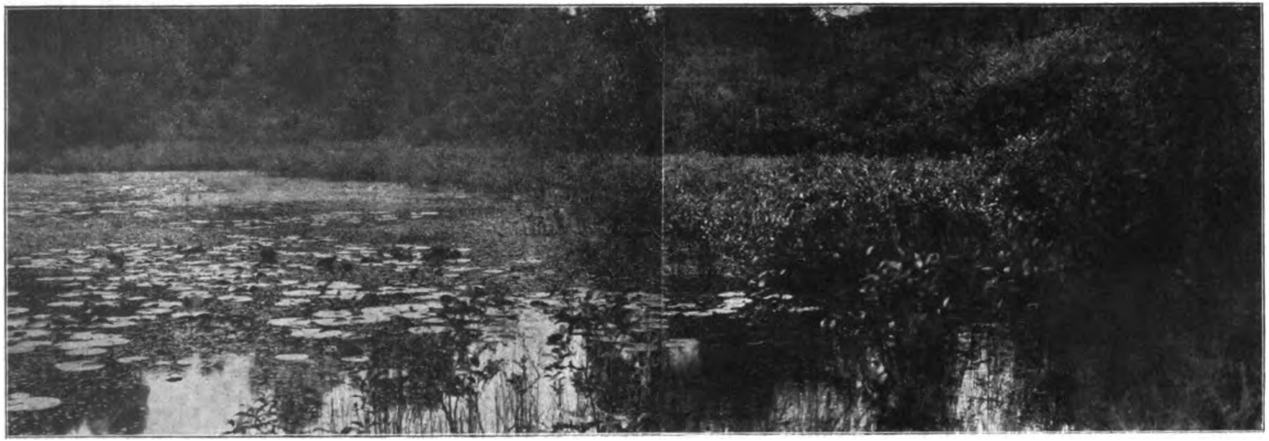

FIG. 5. Looking west across the northern part of the Lily Pond. Beginning at the left is the *Castalia-Nymphaea* Formation somewhat mixed with the *Potamogeton* Formation and consecutively to the right may be seen the *Decodon-Persicaria*, *Cephalanthus-Cornus*, *Rhus hirta*, and *Ulmus-Acer* Formations.

In the course of time the soil may have accumulated to such an extent that the shallower water may offer conditions suitable for other species than those of the resident formation and, by invasion and ecesis, another formation may eventually occupy the habitat. In the Lily Pond the formation next outside of the lily zone is the following:

The *Decodon-Persicaria* Formation.

Facies: *Decodon verticillatus*,
Persicaria laurina.

Secondary Species:

Naumbergia thyrsiflora, *Alisma plantago-aquatica*,
Solanum dulcamara, *Cephalanthus occidentalis*,
Pontederia cordata, *Sagittaria latifolia*,
Nymphaea advena.

Further study of this formation might, perhaps, result in the placing of *Persicaria laurina* as a principal species, but it probably is best regarded as one of the facies. The *Decodon-Persicaria* Formation forms soil quite rapidly and upon the emergence of the soil above the ordinary water level the following structure takes possession:

The *Cephalanthus-Cornus* Thicket Formation.

Facies: *Cephalanthus occidentalis*,
Rosa carolina,
Cornus stolonifera.

Secondary Species:

Salix lucida, *Persicaria laurina*,
Salix cordata, *Alisma plantago-aquatica*,
Lathyrus palustris, *Scirpus americana*,
Typha latifolia, *Eleocharis intermedia*,
Calamagrostis canadensis, *Lathyrus palustris.*

Towards the southern end of the pond there is a patch of wet meadow constituting a remnant, probably, of a once somewhat larger *Calamagrostis* Wet Meadow Formation. The latter formation is represented on Presque Isle by the strong *Cladium-Calamagrostis* Wet Meadow Formation, which, on lagoon banks with gentle slopes and correspondingly wide habitat zones, constitutes an important formation following the rushes and preceding the thicket stage . *Cladium* does not appear on Cedar Point but the *Calamagrostis canadensis* Wet Meadow Formation, really a consocies only of the northward-ranging *Cladium-Calamagrostis* formation, is well developed in the Cedar Point marsh succession and will be discussed further under that head.

In the *Cephalanthus-Cornus* Thicket Formation there is usually more or less of a mixture of the facies but sometimes a more definite structure is evident. Where there is a segregation of the facies into definite structures the *Cephalanthus occidentalis* Consocies occupies the part of the habitat adjoining and grading into the *Decodon-Persicaria* habitat, while the other two facies alternate with each other in the outer more mesophytic part of the habitat. The formation is here bordered by a shrub formation which is approaching old age and which may more properly be regarded as a bordering thicket associated normally with the *Calamagrostis* Wet Meadow Formation.

The Rhus hirta Thicket Formation.

Facies: *Rhus hirta.*
Secondary Species:

Cornus amomum,	*Cornus stolonifera,*
Salix cordata,	*Salix nigra,*
Salix amygdaloides,	*Salix lucida,*
Vitis vulpina,	*Parthenocissus quinquefolia.*
Dryopteris thelypteris,	*Rubus nigrobaccus.*

This formation apparently displaces the *Salix* (*spp.*) Formation where dryer and more mesophytic conditions are approached. This also represents a consocies of a more northern formation which on Presque Isle was of considerable importance and was there designated as the *Rhus-Alnus* Thicket Formation.

The *Ulmus-Acer* Forest Formation.

There are evidences that this formation will come in instead of the *Quercus velutina-imbricaria* Forest Formation in the zone first occupied by the *Populus-Salix* Formation. The elevation of the water table and the consequent hydrophytic tendency of this habitat probably has something to do with the exclusion of the oak forest from this zone. Where the cotton-woods have built up a steep ridge in close proximity to the water, as on the east side of the Lily Pond, the vegetation will, of course, be more xerophytic and will follow the stages as indicated for the ridge succession, finally passing into the oak forest and this will not pass into the *Ulmus-Acer* forest until considerably more mesophytic or even semi-hydrophytic conditions prevail by the accumulation of much humus or by the rise of the water table, or both.

To the southwest of this pond there is a small narrow pond almost choked up with vegetation, the whole being somewhat further developed in its successional stages. The *Cephalanthus-Cornus* Thicket Formation is strongly developed and, in the course of a few years, unless the rise of the water is too rapid, the shrubs will have occupied the whole central portion of the depression.

Previous to the construction of the artificial canals or "Lagoons" in connection with the amusement features of the pleasure resort there were other lagoons between the ridges in advanced stages of the lagoon succession, mostly in the thicket and forest stages although the rise of the water seems to have brought about marsh conditions in places. These older lagoons were not much studied as to the structure of their vegetation before they were destroyed by the dredging out of the artificial canals.

To the left of the path leading to the Eastland Dock and not far from the outlet of the artificial "Lagoons" is a small depression which is interesting in that it represents a secondary pond or lagoon succession. The rise of water in the Lake has finally brought about the rise of the water table into the bottom of a depression which was formerly dry land and there will accordingly follow in due time, the displacement of the present *Ulmus-Acer* forest by a secondary hydrophytic succession.

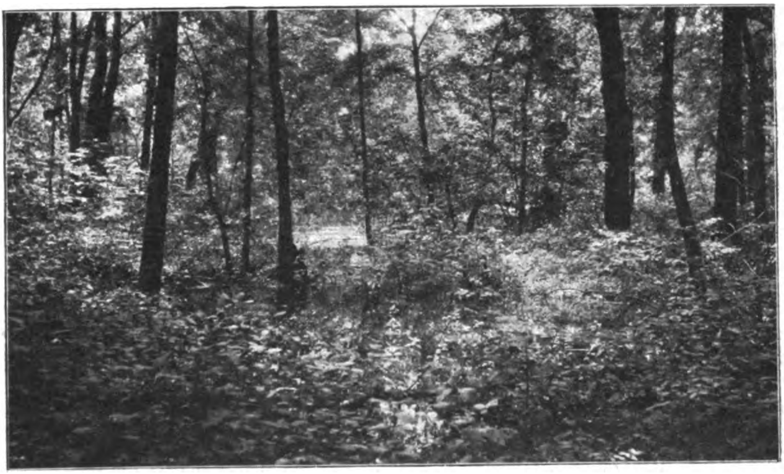

FIG. 6. Depression between outlet of "Lagoons" and the path to the Eastland Dock.

The present vegetation in and immediately around the water is as follows:

Primary Layer:

Acer saccharinum, (perhaps some A. rubrum)	60%,
Ulmus americana	15%,
Platanus occidentalis	15%,
Fraxinus americana	10%,

Fraxinus nigra, one small tree.

Subordinate Layers: Below the primary layer there appear to be only species from the lower layers of the surrounding forest formation, with the one exception that in the pond is considerable *Lemna trisulca*. Around the borders of the pond is a vigorous growth of the following species from the adjoining forest formation:

Impatiens biflora,
Dryopteris spinulosa,
Dryopteris thelypteris,
Geranium robertianum,
Adicea pumila,
Washingtonia claytoni.

Back of the cottages near the Government Dock there is a swampy area which evidently represents advanced stages of the lagoon succession in a lagoon which must have been initiated during severe northwest storms in the Bay. The depression is long and narrow and runs almost at right angles to the general direction of the large sand ridges of the Ridge Section, and is very nearly parallel to the general direction of the shoreline of the Bay near by. The vegetational structure of this depression is approximately a *Calamagrostis* Wet Meadow Formation in the central portion and rapidly invading this area from the sides is the *Cephalanthus-Cornus* Thicket Formation, around which, and in many places in which, is a strongly developed *Rhus hirta* Thicket Formation.

THE-BEACH-SAND PLAIN-THICKET-FOREST SUCCESSION.

In the time intervals between the initiation of the great sand ridges on Cedar Point there was, evidently, a gradual accumulation of sand along the beach of the Ridge Section of the peninsula, causing an outward growth of the land form without the building up of ridges, or, if ridges were initiated by the cutting off of lagoons, the sand drifted in from the adjoining land and from the new beach to such an extent that the lagoons were soon filled, the final result being, in either case, a level expanse of sand plain elevated but a few feet above the level of Lake Erie.

A considerable portion of Cedar Point consists of what may be called Sand Plain. This habitat comprises: (a), the level expanses between the ridges of the Ridge Section; (b), the main part of the Bar Section; and (c), a large proportion of the Dune Section, including also the more or less transitional portion of the peninsula between the Dune Section and the Ridge Section where part of the amusement tents and trinket stands of the Pleasure Resort are located. It is very difficult at times to draw more than an arbitrary line between sand plain and dune, especially in the Dune Section; both these physiographic structures owe their elevation above Lake level to the accumulation of wind drifted sand and differences of topography rather than of origin must be taken into consideration when an attempt is made at classification.

The Lower Beach—The *Chlamydomonas* Formation.

Following in part Cowles' classification[12] of the beach habitats, there may be distinguished, first, the Lower Beach,[13] comprising that part of the beach washed by the waves of ordinary summer storms and thus, chiefly by reason of the mechanical violence of the waves and the instability of the sub-stratum, practically devoid of plant life. However, as Cowles noted along the lower beach of Lake Michigan and as the writer found also on the Lower Beach of Presque Isle, a species of *Chlamydomonas*, a one-celled motile alga, occasionally occurs so abundantly in the sand as to cause a distinctly green coloration These plants are perhaps more correctly to be regarded as migrants from the waters of the Lake, but, being so abundant in certain wet periods and being also the only plant found commonly in the habitat, we have termed the formation the *Chlamydomonas* Formation.

The Drift Beach—The *Cakile-Xanthium* Formation.

Extending from the upper limit of the waves of ordinary summer storms, i. e., the upper edge of the Lower Beach, up to the upper limit of the waves of severe winter storms, there is a zone which may be termed the *Drift Beach*,[14] which is characterized ordinarily by freedom from the violence of the waves of summer storms but is subjected to severe mechanical action of the waves of winter storms, at which time there is usually left a line of driftwood which marks, through the following season, the upper extent of the wave action.

The habitat as thus characterized is inhabited by a vegetation composed of such annuals as can endure the summer environment, the seeds having been left in their present position by wave action. Perennials and biennials are, of course, barred from this habitat by the destructive effects of wave action during the winter. The habitat presents above the surface of the sand conditions of excessive insolation, great and often very sudden extremes of temperature, great fluctuation in the water content of the air, and, also, high winds, and is thus distinctly xerophytic. The edaphic conditions are, however, distinctly hydrophytic below the surface layer of sand so that the habitat may, as a whole, be designated as dissophytic.[15] The vegetation here consists, then, of dissophytic annuals, constituting as determined by the facies the *Cakile-Xanthium* Formation:

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[12] Cowles, H. C. The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan. Bot. Gaz. 27 : 95–117, 167–202, 281-303, and 361–391. Feb., Mar., Apr., and May, 1899.

[13] Cowles, H. C. l. c. Bot. Gaz. 27 : 114–117.

[14] MacMillan's "Mid-strand" (Lake of the Woods); Schimper's "Mid-shore"; Cowles' "Middle Beach" (Lake Michigan); Ganong's "New Beach" (Miscou Island); are all synonyms for the habitat here designated as the Drift Beach.

[15] See Clements—Research Methods in Ecology.

Facies: *Cakile edentula,*
Xanthium commune,[16]
Polanisia graveolens.

Principal Species: *Strophostyles helvola.*

Secondary Species:
Cenchrus tribuloides, *Euphorbia polygonifolia.*

There is considerable alternation in this formation, the *Cakile edentula* Consocies occupying the more exposed Lake beach, while the *Xanthium commune* Consocies is best seen in places along the less exposed Bay beach. *Polanisia* is more indifferent as to its location, it occurring sometimes alone but more usually indiscriminately mixed with the other facies.

The Sand Plain—The *Artemisia-Panicum* Formation.

Where the continuity of the outward growth of the land form of the peninsula has not been broken by the formation of a sand ridge it is often difficult to draw the line between the upper limit of the Drift Beach and the lower limit of the Sand Plain.[17] Upon the burial of the driftwood which accumulates in the upper part of the Drift Beach by the indrifting of sand, the land becomes sufficiently elevated to form a slightly different habitat which is, of course, free from the mechanical violence of the waves at any time, other than at very rare periods. The habitat thus may support a vegetation of annuals, biennials, and perennials, depending simply upon their ability to cope with the otherwise severe conditions of environment.

The vegetation of the Sand Plain may, from its facies, be designated as the *Artemisia-Panicum* Formation. It has essentially the following structure:

Facies: *Artemisia caudata,*
Panicum virgatum.

Principal Species:
Salix interior & var. wheeleri.
Arenaria serpyllifolia,
Arabis lyrata.

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[16] This species is probably best denominated as *Xanthium commune,* rather than as *X. canadense,* as given in the Flora of Cedar Point.—W. A. Kellerman and O. E. Jennings. Ohio Nat. 4 : 186–190. June, 1904.

[17] Synonymous habitats with this are Macmillan's "Back Strand" (Lake of the Woods); Cowles' "Upper Beach" (Lake Michigan); and Ganong's "Grass Plain" (Miscou Island).

Secondary Species:

- *Opuntia humifusa,*
- *Oenothera biennis,*
- *Asclepias syriaca,*
- *Cyperus schweinitzii,*
- *Euphorbia polygonifolia,*
- *Acerates viridiflora,*
- *Asclepias tuberosa,*
- *Oenothera oakesiana,*
- *Andropogon furcatus,*
- *Panicum scribnerianum,*
- *Arabis canadensis,*
- *Apocynum cannabinum,*
- *Ceratodon purpureus,*
- *Cladonia sp.*

Species belonging more properly to other adjoining formations are as follows:

- *Quercus velutina,*
- *Ptelea trifoliata,*
- *Toxicodendron pubescens,*
- *Polanisia graveolens,*
- *Quercus imbricaria,*
- *Rhus aromatica,*
- *Arctostaphylos uva-ursi,*
- *Strophostyles helvola.*

The willow appears in places to dominate the formation during a good part of the growing period and under such conditions may de designated the *Salix interior* Society. Over limited areas of the older and more protected parts of the Sand Plain the *Arenaria serpyllifolia* Society and the *Arabis lyrata* Society characterize quite conspicuous vernal aspects.

The minor structure of this formation requires much further study. Especially after a careful instrumental determination of the environmental characteristics of the various parts of the habitat, a considerable modification might be found necessary. Among the more prominent characters displayed among component species of the formation may be mentioned the relatively large proportion of biennials and perennials. The formation during the hot portion of the summer is subjected to extremely severe and xerophytic conditions, at least during short periods, and it is probably to this that the structure af the vegetational formation is due. The formation is essentially an open structure and often displays prominent ecological families and communities as, for instance, with *Opuntia humifusa*, *Asclepias tuberosa*, etc.

Certain instrumental observations were made in parts of the sand plain during the summer of 1905 as to temperature, relative humidity, etc., and, as showing the extremely xerophytic conditions to which the plants of the sand plain are exposed at times, the following records may be of interest. On a day in middle August, 1905, in one of the open spaces between the advance guard of the oak forest north of the Laboratory where the slight breeze was so faint as to be inappreciable, the temperature of the air at a height of 1½ feet was 83 degrees Fahrenheit, while the sand at the surface just beside one of the communities of *Opuntia humifusa* was 142 degrees, taken at 1:30 P. M., while the maximum temperature for the day reported by the U. S. Weather Bureau

Station at Sandusky, about three miles distant across the Bay was 79 degrees, Fahr. (At 1 inch above the surface of the soil the air was 118 degrees; at 6 inches, 89; at 12 inches 84,—thermometer properly shaded.)

Thus far the vegetational structure in the succession under consideration has been comparatively uniform over the entire Sand Plain wherever the latter may be situated on the peninsula, but the *Artemisia-Panicum* Formation may be invaded and eventually succeeded by a formation having distinctly northern phytogeographical relationships, or, on the other hand, the succeeding formation may be one of more southern affinities.

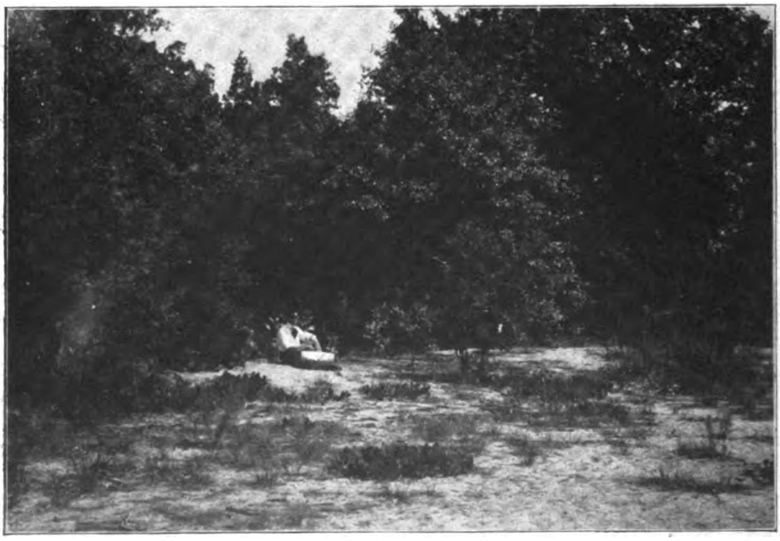

FIG. 7. Small area of Sand Plain enclosed by *Quercus velutina* and *Q. imbricaria*, *Celtis occidentalis*. Note communities of *Opuntia humifusa* with scattering *Artemisia*, *Panicum virgatum*, *P. scribnerianum* and *Verbascum thapsus*.

In the work on Presque Isle the writer found a considerable difference in both the habitat and in the corresponding vegetation in different portions of the Sand Plain such that two formational series could be distinguished as early in the succession as the Drift Beach. On Cedar Point, however, there are no such evident distinctions early in the succession but the critical period appears to be in the sand plain stage.

Accordingly, the succeeding vegetational structures with a more southern phytogeographical relationship will first be taken up, after which the structures of northern affinities will be discussed. The final decision as to the influences determining whether the one or the other phytogeographical element shall predominate must be deferred until exact instrumental determinations may have been made of the various environmental factors in the different parts of the Sand Plain, but, if an opinion may be here ventured, it seems probable that the ecological conditions are so nearly equally suitable for the two elements that historical considerations become of prime importance, and that a very slight fluctuation of the ensemble of ecological factors from one direction to the other may be sufficient to determine which vegetation shall gain the ascendency.

The vegetation of the Bar Section. as so well described by Moseley consists almost entirely of the *Artemisia-Panicum* Sand Plain Formation, there being on the Bay side a narrow strip of more hydrophytic vegetation just at the edge of the marsh. The whole bar is shifting over onto the marsh and it appears likely that the conditions do not reach such a state of stability as to permit the development of a well market thicket stage. Instead of an outward growth of the land form towards the Lake there is here exactly the opposite taking place and the real succession of habitats is abnormal, being from marsh through sand plain to beach.

At the south end of the small peninsula between Biemiller's Cove and the Bay there is a small area of the *Artemisia-Panicum* Formation, but there is no very well marked area of sand plain of any considerable size in the Dune Section, small areas being scattered here and there between the dunes and blow-outs and in the oak forest. Between the Dune Section and the Ridge Section are limited areas of a thicket stage which may be called the

Rhus-Prunus-Toxicodendron Thicket Formation.

The apparent facies being:
Rhus aromatica,
Prunus virginiana,
Toxicodendron pubescens.

This thicket formation is soon followed by the

Quercus velutina-imbricaria Forest Formation,

this having here essentially the same structure as described for the Ridge Succession. The thicket formation succeeding the *Artemisia-Panicum* Formation on Cedar Point is not nearly so prominent or vigorous a structure as is the corresponding *Myrica* Thicket Formation of Presque Isle.

Taking up now the succession of northern phytogeographic affinities we have, as follows:

THE BEACH-SAND PLAIN-HEATH-FOREST SUCCESSION.

This is the more common succession on the Cedar Point sand plain where the habitat is of several years duration. It is doubtful, if this succession were introduced onto the Bar Section, that it could reach maturity. In the Dune Section the heath and forest stages are essentially identical with the dunes and blowouts and, as the former often merge imperceptibly into the latter two formations the discussion of these stages will be taken up in connection with the discussion of the dune and blowout vegetation.

THE DUNE AND BLOWOUT SUCCESSIONS.

Under the above heading may be included a number of secondary formations which, taken together, make up most of the vegetation of the Dune Section of Cedar Point. As Moseley has pointed out,[18] this part of the peninsula represents a portion of the original mainland upon which has been heaped the loose sand, coincident with the rise of the waters of the Lake. There can be no doubt that the land was originally covered here with forest, probably an *Ulmus-Acer* forest formation, which later perhaps gave way to marsh vegetation but upon which, still later, has been heaped the loose sand bringing about conditions suitable for the present dune and blowout formations.

The *Ammophila* Fringing-Dune Formation.

Along most of the Lake shore of the Dune Section the Drift Beach extends up to a well-marked *Ammophila* fringing dune. This species of grass has the ability to grow upwards for a number of feet if continuously buried more deeply by accumulating sand and as the sand accumulates around the ever higher obstruction a gently sloping ridge is finally built up. The height of such a dune or ridge is determined by the height to which the grass can grow vertically, the amount of obstruction which it offers the drifting sand, and, finally, the force of the wind which tends to tear the dune down again.

The structure of the *Ammophila* Fringing-Dune Formation is quite simple:

Facies: *Ammophila arenaria.*
Principal Species: *Psilocybe ammophila.*
Secondary Species:
Euphorbia polygonifolia,
Artemisia caudata,
Cakile edentula,
Salix interior.
Andropogon scoparius,
Strophostyles helvola,
Panicum virgatum,

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[18] Moseley, E. L. l. c. pp. 220–223.

During certain damp periods the agaric appears quite abundantly and can quite appropriately be designated as a principal species characterizing the *Psilocybe ammophila* Society and determining a summer aspect of the formation. The secondary species as may be noticed, are all invaders from the drift beach in front or from the habitat behind the fringing-dune. The secondary species are never very abundant in the dune.

The successor to the fringing-dune is somewhat indefinite. The *Ammophila* apparently dies out as soon as deprived of freshly drifting sand and, in case the beach grows outwards, the grass dies out and the sand is blown away by the wind, or, in some cases other dune plants may successfully invade the dune and hold the sand in place. Among these latter may be mentioned *Elymus* and *Andropogon* and, to some extent, *Arctostaphylos.*

The *Elymus* Dune Formation.

Facies: *Flymus canadensis,*
Elymus striatus.

Secondary Species:
Euphorbia polygonifolia,
Andropogon scoparius,
Tilia americana,
Artemisia caudata,
Panicum virgatum,
Arctostaphylos uva-ursi.

This formation is quite well represented along the Lake shore to the south of the bathing pavilion of the pleasure resort and it there apparently occupies an old *Ammophila* fringing-dune which has been left somewhat inland by the outward growth of the land form at this place, so that the *Ammophila* has been deprived of freshly drifting beach sand and has died out.

The stage succeeding the *Elymus* Dune Formation is here a mixed formation in which *Tilia americana*[19] and *Juniperus virginiana* are prominent, this formation eventually giving way to the *Quercus velutina-imbricaria* Forest Formation.

The *Andropogon* Dune Formation.

Facies: *Andropogon scoparius,*
(*Andropogon furcatus* also to a limited extent.)

Secondary Species: The secondary species are here about the same as those in the *Elymus* Dune Formation and it is not improbable that these two so-called formations may represent simply consocies of one and the same formation. *Andropogon scoparius,* as is also the case with *Panicum virgatum,* often forms about the separate clumps little dunes sometimes reaching a height of a couple of feet, but these miniature dunes disappear with the death of the grass and do not pass by succession into other vegetational structures.

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[19] Cowles, H. C. l. c. Bot. Gaz. 27 : 361–367. The *Tilia* dunes are along parts of the Lake Michigan dune district an important feature.

The successor to the *Andropogon* Dune Formation may be one of several different structures. In the formation are often to be found invaders, of the following species: ***Prunus virginiana***, ***Juniperus virginiana***, ***Parthenocissus quinquefolia***, ***Arctostaphylos uva-ursi***, ***Ptelea trifoliata***, ***Toxicodendron pubescens***, ***Tecoma radicans***, so that the succeeding stage may be expected to be either a heath or a thicket. The larger part of the vegetation in the middle of the Dune Section corresponds closely to the vegetation of Cowles' "Dune Complex" of the Lake Michigan dune region, and the instability of the sand is here such that a genetic series of the formations is a very difficult problem. However, it appears to the writer that the following formation would normally succeed the grass dune formations in the vicinity of the Lake Laboratory:

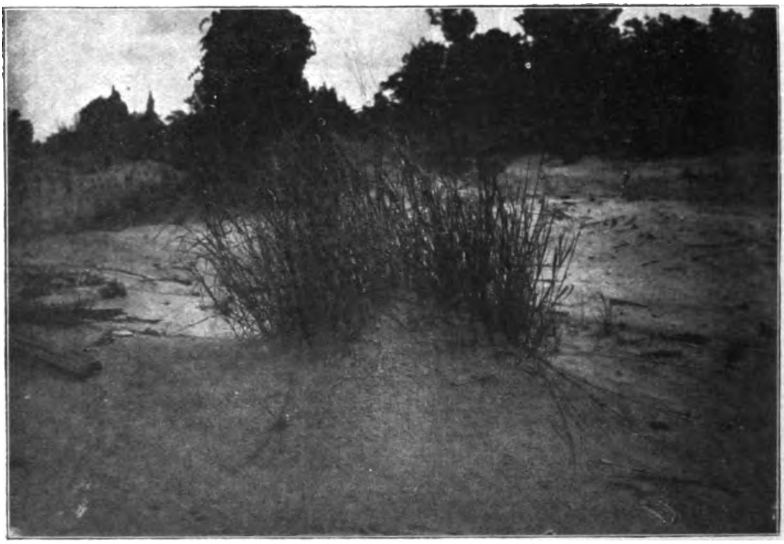

FIG. 8. A miniature dune formed about a clump of *Panicum virgatum*, in a large blowout to the north of the Lake Laboratory.

The *Prunus-Rhus* Dune-Thicket Formation.

Facies: *Prunus virginiana*,
Rhus aromatica,
Ptelea trifoliata.

Principal Species: *Tecoma radicans.*

Secondary Species:

Gleditsia triacanthos,	*Toxicodendron pubescens,*
Parthenocissus quinquefolia,	*Celastrus scandens,*
Juniperus virginiana,	*Prunus serotina,*
Quercus velutina,	*Amelanchier sp.,*
Panicum virgatum,	*Vitis vulpina,*
Andropogon scoparius,	*Artemisia caudata,*
Elymus striatus,	*Rubus nigrobaccus,*
Asclepias syriaca,	

The various dunes scattered about in this section of the peninsula exhibit considerable alternation as to the facies so that there may be distinguished the *Prunus virginiana* Consocies, the *Rhus aromatica* Consocies, and the *Ptelea trifoliata* Consocies. These three structures are, however, often mixed indiscriminately on the same dune.

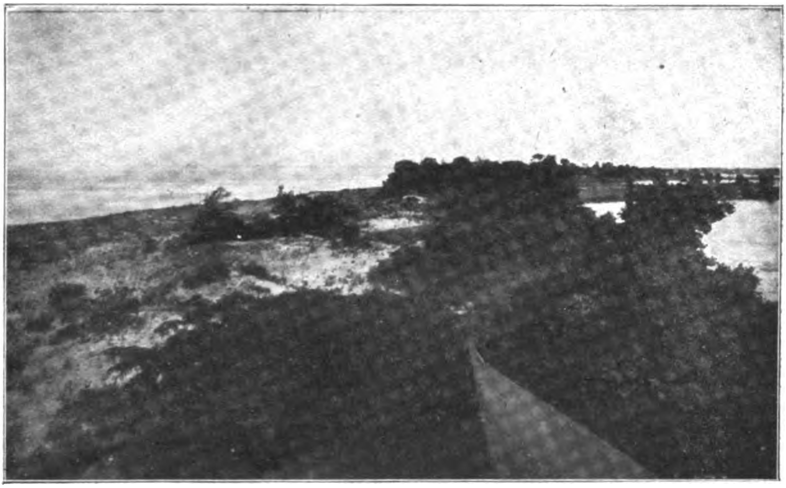

FIG. 9. The Dune Section, looking southwards from the Lake Laboratory. To the left are the dunes and blowouts, between which and the Bay to the right is the forest strip, here mainly consisting of the *Ulmus-Acer* and *Ailanthus* formations. (Photograph by Prof. Herbert Osborn.)

One of the most noteworthy peculiarities of this vegetation is the relatively large percentage of lianas and it is, in many cases, due more to the presence of these plants than to the other vegetation that the integrity of the dune is preserved against the vigorous action of the wind. In fact it appears that many of the dunes were initiated by the lianas or at least held by them until the invasion of the shrubs was accomplished. Especially noticeable in this connection are *Vitis vulpina* and *Parthenocissus quinquefolia.*

If the shore line of the Dune Section were advancing towards the Lake there would in all probability be a corresponding advance of the *Quercus velutina-imbricaria* Forest Formation over the dunes towards the east but, as conditions are at present, there seems to be only in a few places any real advance made by the oak forest and, practically, a state of equilibrium may be said to exist as to this phase of the question.

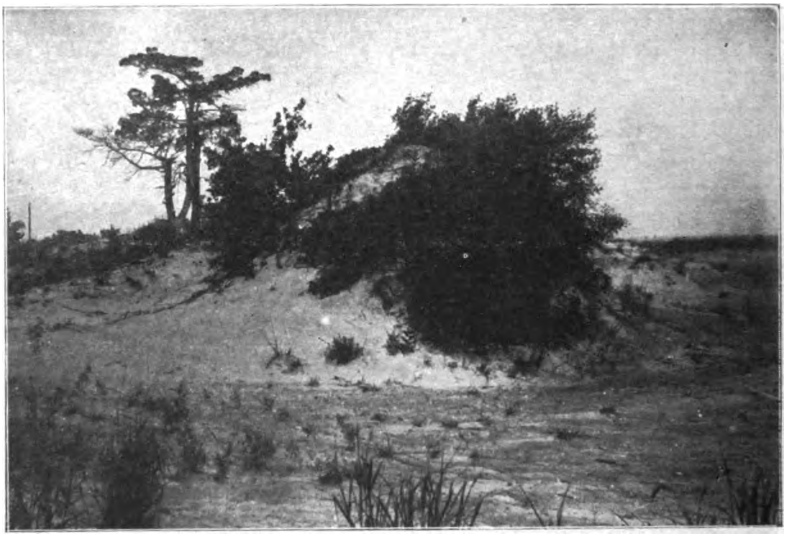

FIG. 10. A dune controlled by the ***Prunus virginiana*** Consocies of the ***Prunus-Rhus*** Dune Thicket Formation. Note secondary species: ***Juniperus virginiana, Asclepias syriaca, Panicum virgatum.*** In blowout surrounding dune note ***Panicum virgatum, Salix interior.*** This dune appears in distance in left third of preceding illustration.

Towards the northern portion of the Dune Section the grass dune formations are followed by a formation consisting of evergreen shrubs with northern phytogeographical relationships, this formation being termed:

The *Arctostaphylos-Juniperus* Heath Formation.

This formation, once established on a dune, brings about more stable conditions than does the *Prunus-Rhus* Thicket Formation. The vegetation being evergreen the winter winds are obstructed much more than is the case with a deciduous dune vegetation and not only are more stable conditions brought about but more sand is deposited by the wind. The structure of this formation is as follows:

Facies: *Arctostaphylos uva-ursi,*
Juniperus virginiana.

Secondary Species:

Andropogon scoparius,	*Panicum virgatum,*
Lithospermum gmelini,	*Quercus imbricaria,*
Quercus velutina,	*Celastrus scandens,*
Toxicodendron pubescens,	*Parthenocissus quinquefolia,*
Rubus procumbens.	

The heath on Presque Isle with somewhat more northern conditions of environment is regularly followed by a white pine forest which, in turn, is regularly replaced by a black oak forest. On Cedar Point, however, the pine stage does not appear to intervene but the heath stage is directly followed by the *Quercus velutina-imbricaria* Forest Formation, typically as described under the Cottonwood Bar-Ridge-Thicket-Forest Succession. In the northern part of the Dune Section there appears to be some advance towards the Lake on the part of the oak forest, young oaks being quite common in the heath at some distance in advance of the mature trees.

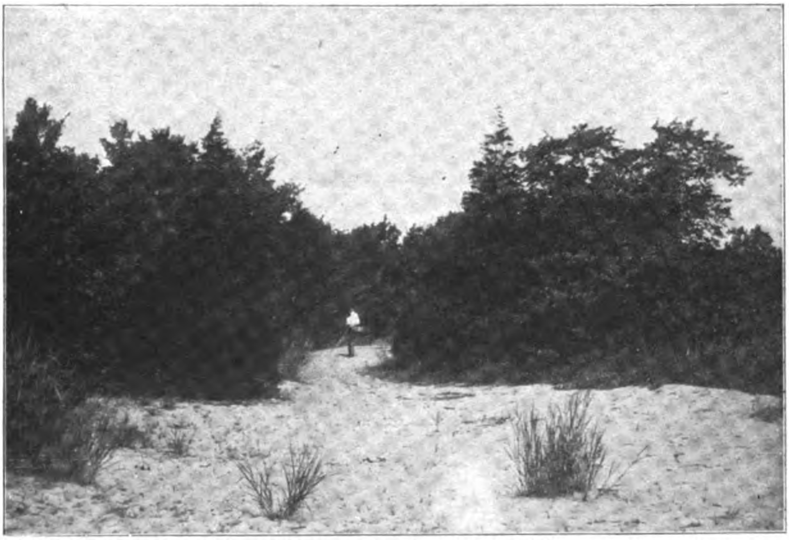

FIG. 11. One of the park-like vistas in the *Quercus velutina-imbricaria* Forest Formation in the northern part of the Dune Section. *Juniperus* and *Celtis* with the oaks, the border thicket being of *Toxicodendron, Rhus aromatica, Prunus virginiana,* while in sand plain are *Panicum virgatum, P. scribnerianum* and *Lepidium virginicum.*

The *Quercus velutina-imbricaria* Forest Formation, however, in this part of the peninsula is far from being a continuous closed forest but is interspersed here and there with areas of open sand plain, giving to the whole a park-like aspect.

The Blowout Formations.

With the formation of dunes by the piling up of sand around the vegetation, there is a tendency towards the deflection of the wind so that its abrasive effect is intensified in open areas in close proximity to the dune. The usual result of this is a hollowing out of the sand at such points, constituting thus a "blowout." Cowles in his work on the sand dunes of Lake Michigan has termed as "fossil beaches" such beach habitats as have been covered over with dune sand or sand plain and later exposed again by the drifting away of the sand.[20]

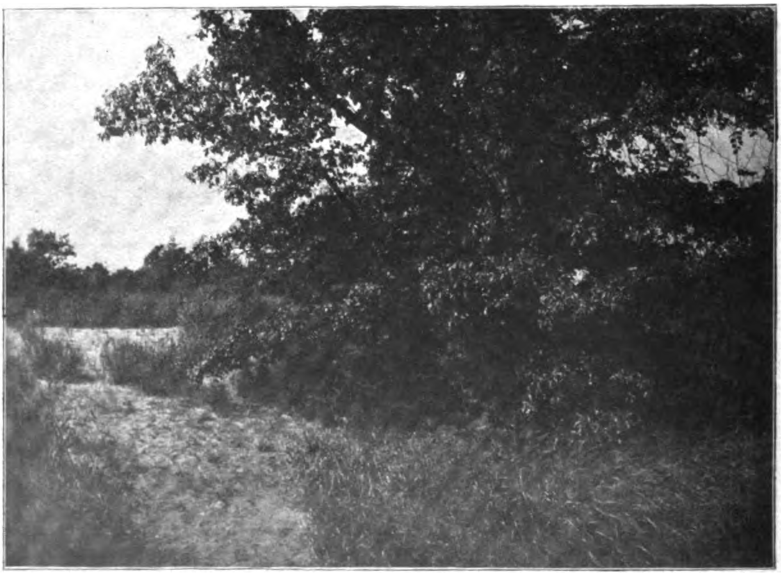

Fig. 12. In Sand Plain at edge of oak forest in northern part of the Dune Section. *Quercus imbricaria* here affords shelter under which many Juniper seedlings are in evidence. This will likely become in time a dune capped by Junipers.

Towards the northern part of the Dune Section the Blowouts are soon occupied by the *Arctostaphylos-Juniperus* Heath Formation as described for the dunes although here perhaps somewhat more vigorous than on the dunes; due perhaps, to the somewhat more sheltered position. Among the secondary species are a few not found in the formation as it appears on the dunes. One plant of *Juniperus nana* appears here, this being probably the extreme southern range of the species, so far reported for America, excepting certain distinctly alpine stations.

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[20] Cowles, H. C. l. c. Bot. Gaz. 27 : 173–175. Fossil Beaches.

In the vicinity of the Lake Laboratory there is a blowout vegetation of a distinctly different character from that of the heath occupying the blowouts farther to the north. Apparently due to the deciduous character of the dune vegetation in the southern part of the Dune Section the blowouts are more pronounced, and, in fact, the dunes are often completely destroyed by the undermining of the sand by a deep adjacent blowout. In many cases the sand has been blown away so that the former beach has been again exposed (fossil beach) and in one blowout to the south of the Laboratory there has been either a wind excavation below the normal Lake level or the water has risen into the bottom of a deep blowout, and there has been initiated there a small lagoon succession.

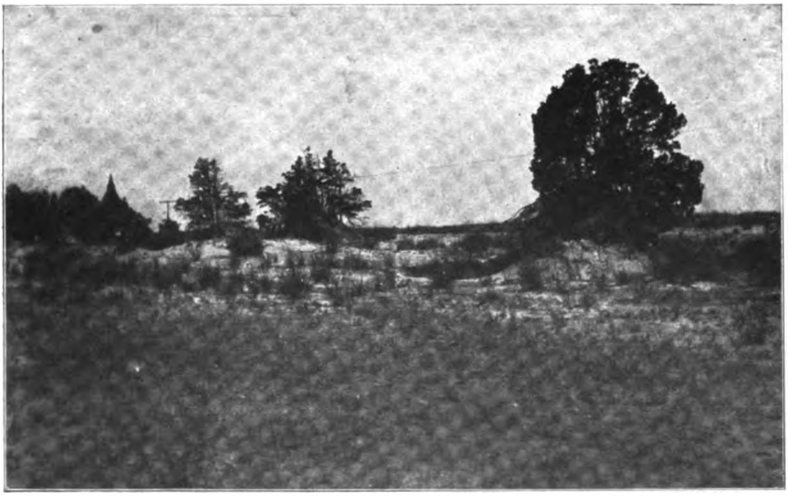

FIG. 13. Juniper-capped dune to the north of the Laboratory. The blowout which includes some "fossil beach" has *Panicum virgatum, P scribnerianum, Andropogon, Salix interior, Lepidium virginicum.*

The blowout vegetation near the Laboratory may probably be best regarded as an extension of the *Artemisia-Panicum* Sand Plain Formation. The same facies are in evidence although the relative importance of the secondary species is considerably different. *Salix interior* and its variety *wheeleri*, *Euphorbia poly-*

gonifolia, and *Oenothera oakesiana* are here more important vegetational elements than they are in the true Sand Plain. The successional stages following such a blowout formation are not clear; generally with the constant shifting of the sand the blowout is filled up with sand before a succeeding stage can become of importance. Perhaps, as in the case of the heath, the oak forest may be able to take possession without the intervention of a thicket stage.

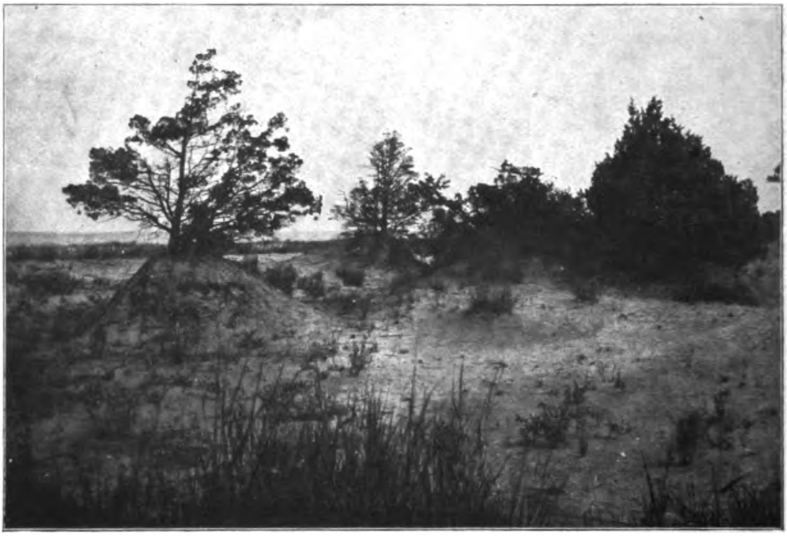

FIG. 14. Juniper-capped dunes north of the Lake Laboratory. The blowout has *Panicum*, *Andropogon*, *Artemisia*, *Salix interior*. At base of dune at extreme right is a small patch of *Arctostaphylos uva-ursi*'

To the north of the Laboratory a short distance the dunes are mostly capped by good sized Junipers and it is plainly to be seen (Figs. 13 and 14) that with the death of these plants the dunes will be quickly destroyed. This locality must in the not distant past have been occupied by an *Arctostaphylos-Juniperus* Heath Formation, but with some sort of a change in the environment the conditions have become such that the deciduous dune and blowout formations have advanced towards the north, the *Juniperus*-capped dunes thus being remnants of a former heath. Possibly the reproduction of Junipers under the protection of vegetation other than the heath, as in Fig. 12 under *Quercus imbricaria*, may be concerned prominently with such conditions.

In the immediate vicinity of the Laboratory there has been initiated a secondary *Catalpa* Blowout Formation by the planting of a considerable grove of Catalpa seedlings for commercial purposes, but, nevertheless, constituting an ecological experiment of more than passing interest. It is too early to yet predict as to the outcome but it appears probable that the trees will succeed if their roots can once become established in lower layers of sand with abundant and never failing ground-water near at hand. If successful and permitted to reach considerable size, dune formation will likely take place on a rather extensive scale and eventually, if allowed to run its course, the place would become an elevated more or less level area with a *Quercus velutina imbricaria* Forest Formation such as in the area now occupied by the buildings of the pleasure resort.

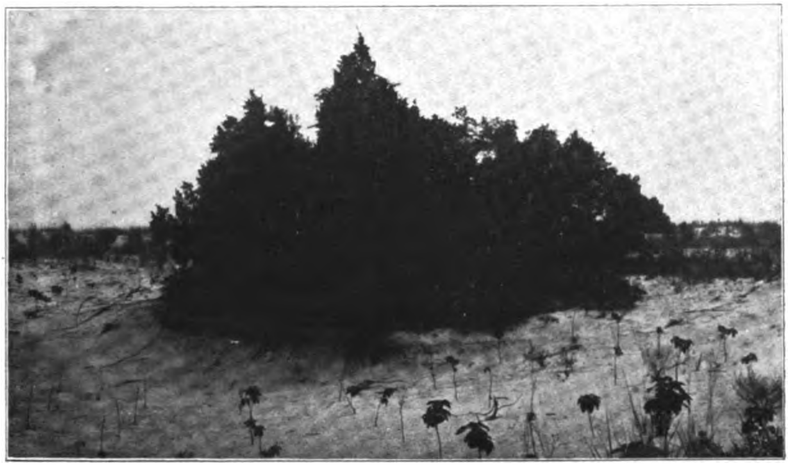

Fig. 15. Secondary *Catalpa* Blowout Formation showing dead plants where the sweep of the wind has induced excessive transpiration.

THE BAY-MARSH-WET MEADOW-THICKET-FOREST SUCCESSION.

Along the western side of the peninsula the vegetational structures represent a variety of conditions of environment which may be classed in a general way under three heads:

1. The Beach Habitat. This habitat includes those portions of the shore which are exposed fully to the action of the surf and from which the water deepens outwards with comparative rapidity.
2. The Marsh Habitat. This habitat comprises those portions of the shore which are comparatively free from the action of violent surf and from which the water deepens outwards from the land very slowly.

3. The Cove Habitat. This habitat comprises those portions of the Bay which are enclosed by peninsulas, etc., in such a manner as to be protected from the action of currents and surf, and in which the water is several feet at least in depth.

The Beach Habitat.

This structure is practically the same beach as is to be found along the Lake shore of the peninsula, although less strongly developed. It has also the same vegetational formations somewhat less well developed and so will not need here a separate discussion. This habitat comprises much of the western shore of the peninsula, northwards from the end of the small peninsula at the entrance to Biemiller's Cove.

The Marsh Habitat.

This structure is exceedingly well developed between the Bar Section of Cedar Point and the mainland to the south and west, embracing altogether hundreds of acres of pure marsh. From Moseley's researches it appears certain that portions of this marsh have remained marsh for hundreds of years, the accumulation of vegetable debris, transformed into muck, having been so nearly equal to the cumulative rise of water that the marsh vegetation has been able to successfully hold the habitat against all invaders for a very long period. It is further to be remembered that this area was formerly a part of the mainland and at one time covered with forest which was eventually killed by the rise of the water, the marsh then taking its place, perhaps an intervening thicket first appearing. The retarding of the currents of the streams entering the marsh at the present and the occurrence of marsh thickets and pure marshes along the retarded and widening stream are at present indicative of the method of origin of the marsh.

The structure of the vegetation in the Marsh Habitat may be analyzed thus:

a. The *Scirpus* Formation,
b. The *Phragmites-Typha* Marsh Formation,
c. The *Salix discolor-lucida* Thicket Formation,
    or the *Calamagrostis* Wet Meadow Formation,
d. The *Rhus hirta* Thicket Formation,
e. The *Ulmus-Acer* Forest Formation.

The *Scirpus* Formation.

This formation is nearly related to the *Typha-Scirpus* formation of the Lagoon Succession but, as we have pointed out for Presque Isle, there is a separation of the two species of that formation when the conditions of the Marsh Habitat are attained. *Scirpus validus* and *Scirpus americanus* are morphologically so constructed as to have a life-form very little affected by surf, the long, cylindrical, stiff, but yet quite flexible, stems being admirably adapted to withstand surf conditions in which the larger, less flexible leaves and stems of *Typha* with a greater surface exposed to the action of the surf, would be broken up and the plant killed. Accordingly we find that part of the marsh exposed to the action of the surf to have the following structure:

Facies: *Scirpus validus,*
Scirpus americanus.
Principal Species: *Dianthera americana.*

Within the formation there is a distinct zonation, the *Scirpus validus* Consocies occupying the deeper water, often to a depth of four or five feet, while the *Scirpus americanus* Consocies occupies the shallower portion of the habitat, often extending, where the bottom is sandy, out to the water's edge or even onto the wet bank, but on a muck bottom it is usually replaced in water a foot or less in depth by the formation next described. The action of the surf is considerably diminished by stretches of this formation and quite considerable quantities of shifting sand may be stopped and accumulated by the rushes, thus building up the land.

The *Dianthera americana* Society occurs in a few places in the habitat of the *Scirpus americanus* Consocies, being best developed on sand-bars or islands submerged a few inches and over which which there is usually more or less of a current,—practically the condition of a river sand-bar where this plant reaches its best development. The submerged bar along the south side of the entrance to Biemiller's Cove shows this Society very nicely.

With the accumulation of sand and the consequent shallowing of the water, often also with the accumulation of more or less well defined deposits of partially humified muck, the following formation succeeds the *Scirpus* Formation:

The *Phragmites-Typha* Marsh Formation.

Facies: *Typha latifolia,*
Phragmites phragmites.
Secondary Species:

Zizania aquatica,
Sagittaria latifolia,
Sparganium eurycarpum,
Solanum dulcamara,
Nymphaea advena,
Lemna trisulca,
Carex aquatilis,
Salix sp.,
Scirpus americanus,
Persicaria laurina,
Calamagrostis canadensis,
Naumbergia thyrsiflora,
Dulichium arundinaceum,
Wolffia columbiana,
Carex comosa,
Cephalanthus occidentalis,

Many of the secondary species of this formation are more or less temporary invaders belonging more properly to other formations. The larger part of the formation is made up of the facies alone, the *Typha latifolia* Consocies being found in the deeper water and in perhaps more exposed positions than is the *Phragmites phragmites* Consocies.

The immense accumulation of muck underlying this marsh is likely the product of the accumulation and subsequent more or less complete humification of the remains of the plants of this formation. The annual growth of these plants constitutes a large quantity of vegetable matter which, upon its death, is placed in most favorable conditions for its retention and subsequent humification. In places where the accumulation of humus has been so rapid as to raise the level of the soil above the water or, as along the edge of the Bar Section, where sand drifts in and helps to build up the soil, there follows a succession by either the *Calamagrostis canadensis* Wet Meadow Formation or by the *Salix discolor-lucida* Thicket Formation.

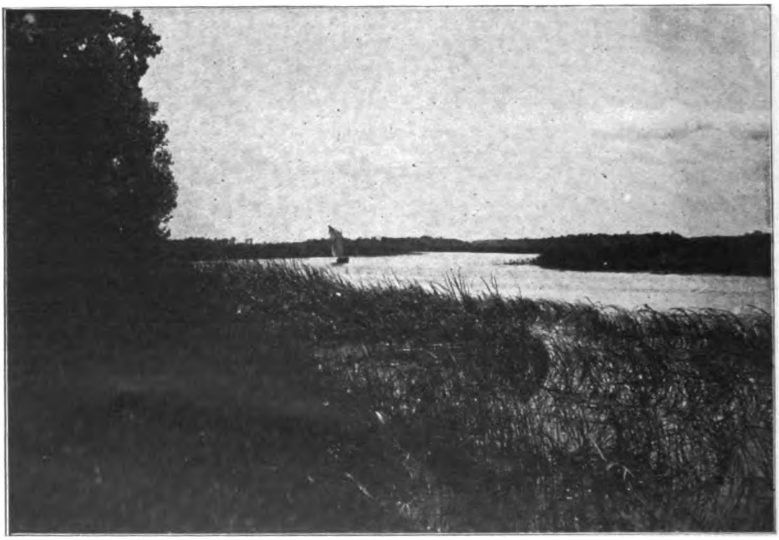

FIG. 16. The Black Channel and the *Phragmites-Typha* Marsh Formation. The forests in the far distance are at the edge of the mainland on the other border of the marsh more than two miles distant.

The *Salix discolor-lucida* Thicket Formation.

There are no very well marked examples of this formation and its structure is not clear to the writer. However, the structure has been correlated with a similar and well-marked formation at Presque Isle, and in the limited areas where it occurs along the Bar Section it agrees well with the Presque Isle formation. It possibly may prove to be the same structure as was called the

"*Salix sp.*" Formation around the lagoon at the northeast corner of the peninsula. As exemplified along the Bar the structure is as follows:

Facies: *Salix discolor*,
Salix lucida,
Salix amygdaloides.
Principal Species: *Solidago canadensis*.
Secondary Species:
Salix cordata,
Cornus amomum,
Rhus hirta,
Cephalanthus occidentalis,
Epilobium adenocaulon,
Impatiens biflora,
Teucrium canadense,
Lycopus americana,
Cornus stolonifera,
Rosa carolina,
Cicuta maculata,
Mimulus ringens,
Stachys aspera,
Thaspium barbinode.

The conditions of environment brought about by a rise in water level are such that xerophytic soil with little humus rapidly passes through the mesophytic to the hydrophytic stage and this is evidently not so well suited to the *Salix discolor-lucida* Thicket Formation as is a similarly situated, humus-rich soil, which, with the elevation due to the accumulation of vegetable humus has passed from hydrophytic to more mesophytic edaphic conditions, as is ordinarily the case around marshes and ponds.

In a few places this shrub formation alternates with the *Calamagrostis* Wet Meadow Formation, but, as this is of comparatively limited extent as compared with the wet meadow occurring in connection with the Cove Habitat near the Laboratory, a discussion of its structure will be taken up under the treatment of the Cove Habitat.

The *Rhus hirta* Thicket Formation.

This formation is sparingly developed along the marsh shore of the Bar Section but it is comparatively not vigorous and does not form areas of any considerable size. It sometimes borders the preceding shrub formation (*Salix discolor-lucida* Thicket Formation) or the wet meadow formation, or it may directly adjoin the *Phragmites-Typha* Marsh Formation. In many places there is a direct transition from the Sand Plain of the Bar Section to the Marsh Formation with no intervening shrub or meadow zone.

The cottonwoods in the Bar Section are not of great age and they have undoubtedly been such as have accomplished ecesis in the edge of the marsh where the disseminules were buried under the indrifting sand; conditions almost identical with those obtaining along the wet bank of a newly formed beach lagoon.

In a few places towards the Dune Section *Ulmus americana* seedlings were found along the shores of the marsh under such conditions as would indicate a possible *Ulmus-Acer* zone as a successor to the shrub zone providing other conditions do not prevent their development. However, if the trend of environmental conditions is to continue indefinitely as in the past there is little probability that this forest zone will be able to mature.

The Cove Habitat.

The Cove Habitat and its vegetation is one of the most marked ecological features of Cedar Point. The completeness of the vegetational structure and the size of the habitat, as exemplified in Biemiller's Cove and in other coves to the south of the Laboratory, are far in advance of anything in this line at Presque Isle and to say the least, the student of cove vegetation will find here exceptionally fine opportunities for such studies. Proceeding from the deepest water towards the shores the general structure of the vegetation may be classified as follows:

a. (The *Chara* Formation.)
b. The *Potamogeton* Formation,
c. The *Castalia-Nymphaea* Formation,
d. The *Phragmites-Typha* Marsh Formation,
e. The *Calamagrostis canadensis* Wet Meadow Formation,
f. The *Cephalanthus-Cornus* Thicket Formation,
g. The *Rhus hirta* Thicket Formation,
h. The *Ulmus-Acer* Forest Formation.

The *Chara* Formation.

A few specimens of *Chara* were found at Presque Isle in situations similar to the Cove Habitat at Cedar Point and Pieters reports more or less complete *Chara* associations in the western end of Lake Erie and in Lake St. Clair, although seldom found where the bottom was sandy.[21] Probably with proper facilities a search of the coves of Cedar Point would reveal a more or less well developed *Chara* formation; although generally sandy, the cove bottoms are not altogether so.

The *Potamogeton* Formation.

This formation is particularly well developed here and, in general, it very closely resembles the corresponding formation at Presque Isle. Its habitat may be said to comprise that part of the cove in which the water is four feet or more in depth, excepting in the deepest portions where the *Chara* Formation may be more characteristic. The coves are likely nowhere so deep as to exclude the latter formation. The structure of the *Potamogeton* Formation is essentially as follows:

---

[21] Pieters, A. J. The Plants of Western Lake Erie with Observations on their Distribution. U. S. Fish Commission, Bull. 1901 : 57–79. and The Plants of Lake St. Clair. Bull. No. 2, Michigan Fish Commission, 1894.

Facies: *Potamogeton perfoliatus,*
Potamogeton lonchites,
Potamogeton pusillus.
Principal Species:
Vallisneria spiralis,
Myriophyllum spicatum.
Secondary Species:

- *Potamogeton natans,*
- *Potamogeton amplifolius,*
- *Naias flexilis,*
- *Castalia tuberosa,*
- *Scirpus validus,*
- *Ceratophyllum demersum.*
- *Potamogeton foliosus,*
- *Potamogeton zosteriaefolius,*
- *Philotria canadensis,*
- *Nymphaea advena,*
- *Nelumbo lutea,*

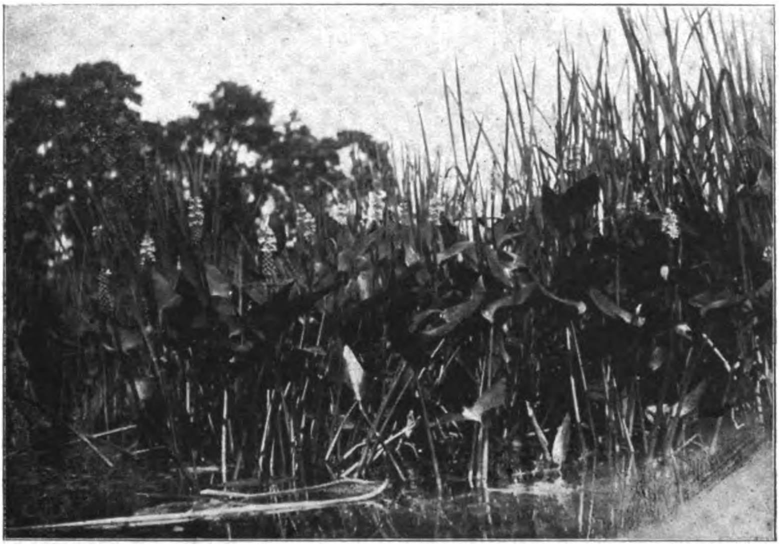

FIG. 17. A *Pontederia cordata* Society along the submerged bar at the south end of Biemiller's Cove. The *Typha latifolia* Consocies of the *Phragmites-Typha* Marsh Formation in the background.

The mass of vegetation comprising this formation is altogether quite large and the water is often so thoroughly filled up with it that, looked at from above, the space appears completely taken up by the vegetation in the middle and lower depths. The conditions are very good for the accumulation of considerable deposits of vegetable debris and for straining out suspended sediments in the water, or for obstructing to some extent floating debris, so as to finally lead to its deposition on the bottom. Under conditions of stable equilibrium, as to the relative position of water level and the land, this formation could be expected in the course of time to build up the bottom to such an extent as to eventually lead to the invasion and occupation of the habitat by the formation to be next described.

The *Castalia-Nymphaea* Formation.

This formation also is well developed in the Cedar Point coves. It occupies a zone next outside of the *Potamogeton* Formation in water of a depth of from one or one-and-one-half feet to four feet. In its outer deeper part it is always much mixed with the *Potamogeton* Formation but aside from that it is a well defined and vigorous structure.

Facies: *Castalia tuberosa*,
Nymphaea advena,
Nelumbo lutea.

Principal Species: *Pontederia cordata*,
Utricularia vulgaris,
Zizania aquatica.

Secondary Species:
Potamogeton natans,
Potamogeton pusillus,
Myriophyllum spicatum,
Sagittaria latifolia,
Naias flexilis,
Typha angustifolia,
Batrachium longirostris.
Potamogeton lonchites,
Bidens beckii,
Philotria canadensis,
Sagittaria graminea,
Typha latifolia,
Phragmites phragmites,

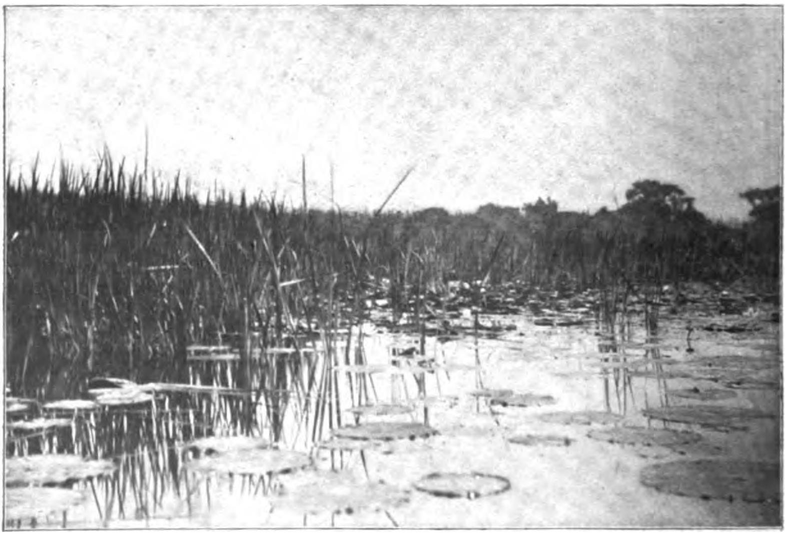

FIG. 18. The *Nymphaea advena* Consocies, here mingled with the *Castalia tuberosa* Consocies, in the second cove south of Biemiller's Cove. *Typha* in the immediate background and *Phragmites* farther back.

The facies of this formation exhibit more or less zonation. *Castalia tuberosa* generally forms a Consocies in the deeper part of the habitat of the formation while the shallower part of the formation often has alternating *Nymphaea advena* Consocies and *Nelumbo lutea* Consocies. Over a large part of the habitat, however, the facies are mingled to such an extent that the consocies structure is not evident.

The *Pontederia cordata* Society is not ordinarily of large extent but the plant usually appears in dense ecological families and communities. This Society is usually associated with the *Nymphaea advena* and the *Nelumbo lutea* Consocies in the shallower water of the habitat.

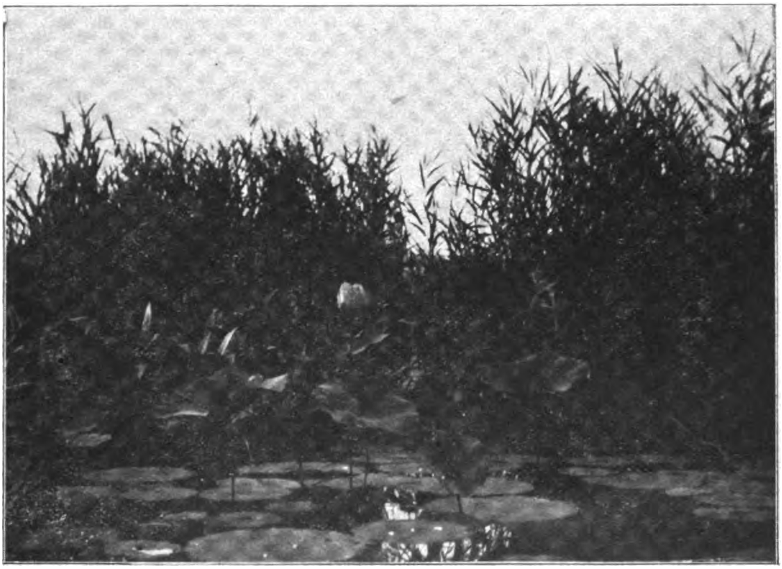

FIG. 19. The *Nelumbo lutea* Consocies mingled in the left background with the *Pontederia cordata* Society. The general background being the *Phragmites phragmites* Consocies of the Marsh Formation. In the third cove south of Biemiller's Cove.

The *Utricularia vulgaris* Society determines a quite conspicuous aspect in midsummer in some of the little bays and inlets opening off from the larger body of the cove into the marsh,—usually in water of not more than six or eight inches in depth with a deep semi-liquid muck bottom.

The *Zizania aquatica* Society determines a conspicuous autumnal aspect almost throughout the whole formation except, perhaps, in the very deepest part. During midsummer this structure only begins to show, but at the fruiting season of the wild rice the habitat of the *Castalia-Nymphaea* formation is conspicuously dominated by the Society.

The *Phragmites-Typha* Marsh Formation.

In the more sheltered habitat afforded around the cove this formation differs from the formation as found in the marsh to the west of the Bar Section in that the *Typha latifolia* Consocies is more prominent. It appears from the writer's observations that the *Typha latifolia* Consocies prefers a soil rich in humus while the *Phragmites phragmites* Consocies, other conditions being equal, prefers a more sandy substratum. On the submerged sand bar which forms the southern boundary of Biemiller's Cove the axis of the bar where about a foot under water is occupied by the *Phragmites phragmites* Consocies, while towards the junction of the bar with the mainland, where there is considerable humus in the soil, the *Typha latifolia* Consocies appears.

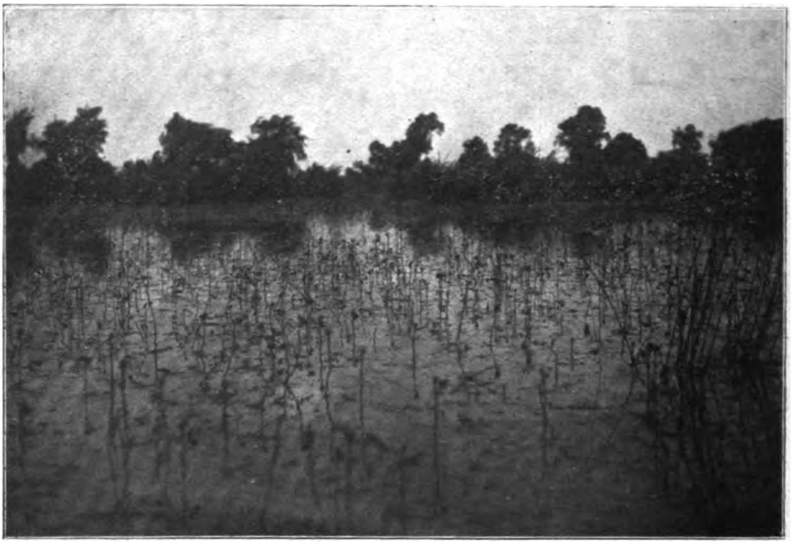

FIG. 20. The *Utricularia vulgaris* Society in one of the larger inlets running into the marsh at the north end of Biemiller's Cove. *Typha latifolia* and *Typha angustifolia* Consocies in the background. *Scirpus americana* at the right.

The composition of the formation as exemplified around the coves is as follows:

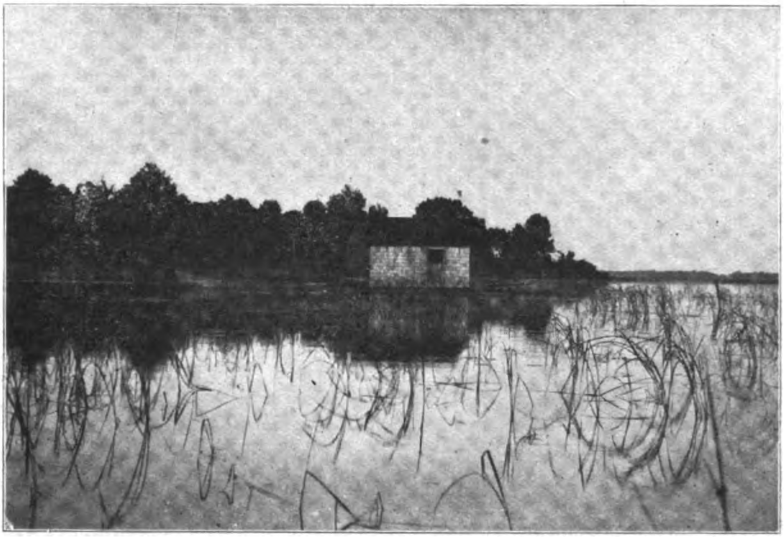

FIG. 21. In fourth cove south of Laboratory, photo taken in late August shows the *Zizania aquatica* Society beginning to appear.

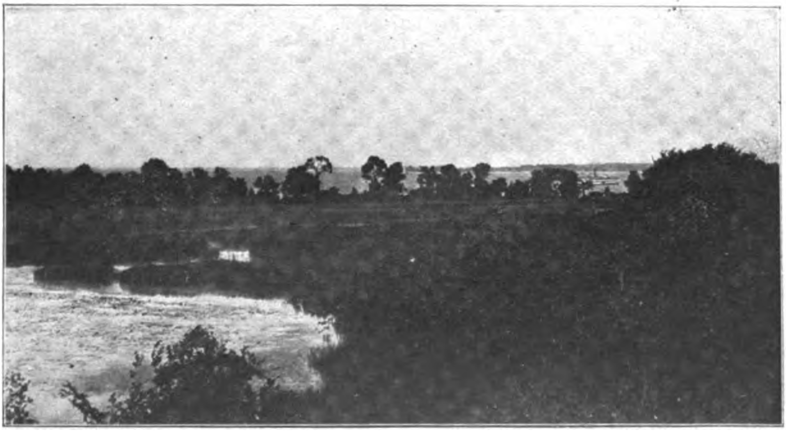

FIG. 22. Looking northwest across the northern part of Biemiller's Cove and the adjoining marsh. *Castalia-Nymphaea* Formation at left in cove. *Typha latifolia* and *Typha angustifolia* Consocies comprise most of marsh. The narrow peninsula in distance occupied by the *Ulmus-Acer* Forest Formation. Photo taken from roof of Laboratory.

Facies: *Typha latifolia,*
Typha angustifolia,
Phragmites phragmites.
Principal Species: *Hibiscus moscheutos.*
Secondary Species:
Zizania aquatica,
Sagittaria latifolia,
Lemna trisulca,
Naumbergia thyrsiflora,
Cornus amomum,
Cephalanthus occidentalis,
Cicuta maculata,
Calamagrostis canadensis,
Dianthera americana,
Sparganium eurycarpum,
Dulichium arundinaceum,
Persicaria laurina,
Cornus obliqua,
Carex comosa,
Solanum dulcamara,
Carex comosa.

This formation, with the building up of the soil above the water level, may give way immediately to a shrub formation but, where there is a considerable extent of wet soil just above the level of the water, there is more likely to be an invasion and subsequent occupation by a wet meadow formation, as follows,—typically exemplified at the eastern border of the marsh to the north west of the Laboratory:

The *Calamagrostis canadensis* Wet Meadow Formation.

Facies: *Calamagrostis canadensis.*
Secondary Species:
Blephariglottis psycodes,
Boltonia asteroides,
Carex schweinitzii,
Carex frankii,
Carex stipata,
Carex bicknellii,
Carex laxiflora,
Cephalanthus occidentalis,
Cornus obliqua,
Dryopteris thelypteris,
Lobelia syphilitica,
Gyrostachys cernua,
Penthorum sedoides,
Roripa hispida,
Rumex crispus,
Rumex obtusifolius,
Salix amygdaloides,
Bidens discoidea,
Campanula uliginosa,
Carex comosa,
Carex lanuginosa,
Carex tribuloides,
Carex lupulina,
Carex vulpinoides,
Cornus amomum,
Sambucus canadensis,
Epilobium adenocaulon,
Lathyrus palustris,
Mimulus ringens,
Onoclea sensibilis,
Roripa palustris,
Rumex verticillatus,
Salix cordata,
Salix lucida, etc.

The list of secondary species in this formation is a very long one, especially when including various invading species from the other formations adjacent, and certain other more or less ruderal species. However, in the real vegetational structure these many species play very little part, the facies constituting almost entirely the bulk of the vegetation.

This formation is apparently a rather rapid soil former and with the elevation of the ground the more mesophytic conditions permit the entrance of the following thicket formation, as around the east side of the area of the *Calamagrostis* Wet Meadow to the northwest of the Laboratory:

The *Cephalanthus-Cornus* Thicket Formation.

Facies: *Cornus amomum,*
Cornus obliqua,
Cephalanthus occidentalis,
Rosa carolina.
Principal Species: *Sambucus canadensis.*
Secondary Species:
Salix cordata,
Salix lucida,
Polygonum convolvulus,
Dryopteris thelypteris,
Ailanthus glandulosa,
Rhus hirta.
Salix amygdaloides,
Calamagrostis canadensis,
Solanum dulcamara,
Platanus occidentalis,
Ulmus americana,

This vegetation should be classed rather as a mixed formation, perhaps, than as a pure one, it apparently being made up of various elements from the other thicket zones on the peninsula. The predominating consocies is the *Cornus amomum-obliqua* Consocies, while during the flowering period of the elderberry the *Sambucus canadensis* Society determines in places a conspicuous aspect.

Along the eastern shore of the marsh and wet meadow formations forming the northward extension of Biemiller's Cove, considerable sand has blown over in places from the peninsula and the bank rises in such places quite abruptly. At such points the *Rhus hirta* Thicket Formation usually occupies this more xerophytic habitat and it, evidently, under such conditions, is succeeded by the *Quercus velutina-imbricaria* Forest Formation.

Where the slope is more gradual, with a more hydrophytic soil, usually also with more humus, the normal succession appears to be from the wet meadow through the *Cephalanthus-Cornus* Thicket Formation to the *Ulmus-Acer* Forest Formation.

The *Ailanthus glandulosa* Forest Formation.

An interesting example of an anomalous succession is afforded in the near vicinity of the Laboratory and at a couple of other stations on the peninsula by the *Ailanthus glandulosa* Forest Formation which is rapidly developing along the shores of the cove and Bay in the Dune Section. This Asiatic ruderal tree now constitutes a prominent zone occupying the habitat of the less hydrophytic of the thicket zones, although often displacing also the *Cephalanthus-Cornus* zone and extending, as well, up the sides of adjacent dunes and onto the adjacent *xerophytic* Sand plain.

Although very successful in competition with the *Cephalanthus-Cornus* and *Rhus hirta* Thicket Formation, it appears probable that this formation will eventually be succeeded by the *Ulmus-Acer* Forest Formation. The structure of the *Ailanthus glandulosa* Forest Formation, as to the lower layers, is intermediate generally between that of the thicket formations that have been supplanted and that of the *Ulmus-Acer* forest. A number of the species, such as *Campanula americana*, belong more especially to the latter formation, but the conditions of dense shade of the Ailanthus forest seem to have supplied the conditions essential for its entrance into this habitat.

Certain secondary successions are to be seen in several places on Cedar Point, as brought about by the agency of man, but these were not studied in detail by the writer. One of these successions has been brought about by the effort made to have a lawn and shrubbery in the vicinity of the buildings of the Pleasure Resort. Another secondary succession marked by the appearance of a number of ruderal species has been brought about by the throwing aside of sand in connection with the dredging of the artificial "Lagoons."

Carnegie Museum, January 20, 1908.

THE MURMAN BIOLOGICAL STATION.

Sergius Morgulis.

To the observer abroad, in Europe and more especially in America, Russia is still vested with clouds of mystery. This is true even with regard to the scientific Russia, slightly known in other countries, which of course is due primarily to the Russian language being familiar only to very few scientists.

This note is intended to acquaint the reader with a neglected scientific institution, of no small rank, and is compiled largely from reports kindly placed in my possession by Dr. K. M. Derjugin, Curator of the Station.

Marine Biological Stations are the workshops of biologists, and ever since students of nature have abandoned their air-tight laboratories, stored up with pickled specimens, and migrated to the shores of the open sea, where they came in direct touch with an exuberant living world, our science has progressed by strides. This "migratory humor" effected also the Russian biologists, and the famous embryologist Kovalevsky succeeded in founding a Biological Laboratory on the coast of the Black

Sea, which soon became an important center for research work in Russia, and gained a world-wide reputation.

We cannot, however, say the same thing about the Murman Biological Station, established only in 1899, as yet very little known, and which, by the way, is often confounded with its unsuccessful predecessor, "The Biological Station of the Solovetsky Monastery."

The history of this Murman Station presents a few interesting features, so characteristic of every Russian "history." In 1882 Prof. Wagner, of the St. Petersburg University, was allowed to carry on investigations on the northern fauna in a fisherman's hut, belonging to the Solovetsky Monastery. This permission he obtained through the courtesy of the Father-superior of the Monastery, which is situated on the Solovetsky Islands, in the middle of the White Sea, a relatively short distance from the Arctic Ocean. Year after year, during the summer months, this fisherman's hut was visited by investigators who studied the rich animal and plant world of this region. In the meantime, the fisherman's hut has undergone considerable change. A few new buildings were added to it at the expense of the Society of Naturalists, and it was made more suitable for scientific work.

After a seventeen years' fruitful existence the laboratory had to be abolished on these islands. The death-blow to the young and growing institution was dealt by the new father-superior of the monastery who denounced the scientific visitors of these islands in his secret report to the office of the Holy Synod, by lodging a complaint that the presence of "impious" scientists acts demoralizingly upon the monks and pilgrims. The father-superior's argument produced its effect, and the nature-students soon packed up their luggage and started out in search for a new settlement in that cold region. Such has been found on the Murman Peninsula where the present Murman Biological Station was established in 1899, and has operated successfully since. They have fairly well equipped laboratories there, aquarium rooms, museum, a reference library containing a few hundred volumes, etc. The station is situated in an attractive rocky locality right on the shore of the Kolsky Bay.

The climate of this region is rather cold, the average yearly temperature not being above 0 degrees Centigrade, but July and Auguts are very comfortably warm months. The flora and fauna is very rich there, and as Prof. Derjugin tells me, there is hardly a case when the dredge does not bring up a multitude of various organisms. There have been listed over 500 representatives of all the classes of invertebrates and fishes, and Hydrozoa, Actinozoa, sea-urchins, star fishes, worms, planarians, nemertines, molluscs, crustaceans, are all very abundant, and their eggs can the unaided eye the apical spot appears to be separated from the crossband, but a lense shows that shaded bands reach across in the marginal and first submarginal cells. The crossband is much abbreviated posteriorly and is broken up into darkened patches in the region of the discal and second and third posterior cells. Throughout the crossband the vein margins are either hyaline or only shaded with brown. Front legs yellow to middle of tibiae from thence black, middle legs yellow, hind legs yellow, with the exception of the bases of the femora which are black. Middle and hind tarsal segments infuscated apically. Abdomen above largely yellow; first segment with a square black spot at middle, second at middle with a wide stripe furcate behind, and a small spot on either side near the hind margin black; third and fourth segments each with four black stripes which do not quite reach the posterior margins; remaining segments black with yellow posterior margins.

A number of females received from Franklin Sherman, Jr., and collected at Highlands, North Carolina. Also a female collected by E. B. Williamson at Hayden, Ontario, July 10, 1906. Two females taken at Highlands, North Carolina, were sent in by C. S. Brimley.

A note from Professor Sherman is of interest in this connection. He stated at the time he sent the specimens that "they appear to be different from anything we have taken in the state. I have taken the species two different years in the same general region in our mountains at an elevation of about 3,000 feet, and although both times I collected them while driving along a road, they were not to be taken, on the same road the same day, when we descended to 2,500 feet or lower."

Date of Publication, December 28, 1907.

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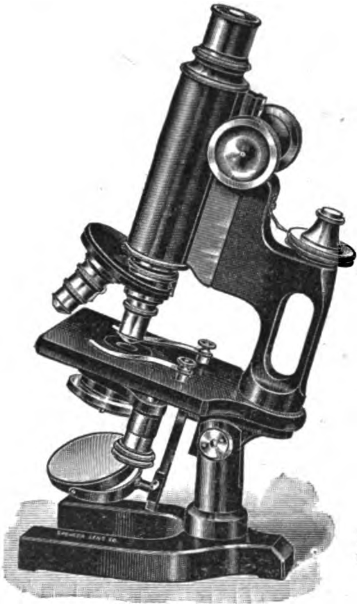

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